OPERATIVE THERAPEUSIS

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EDITED BY

ALEXANDER BRYAN JOHNSON, Ph.B., M.D.

VOLUME II

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JAMES H. KENYON

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OPERATIVE THERAPEUSIS

VOLUME II

CHAPTER I

THE GENERAL ASPECTS OF POSTOPERATIVE TREATMENT, INCLUDING THE RECOGNITION AND TREATMENT OF SHOCK AND HEMORRHAGE

JOHN C. A. GERSTER

For the sake of arriving at a clearer understanding, a brief account will first be given of the normal, uncomplicated postoperative course and care of any case in which general anesthesia has been used; this, to be followed by a detailed consideration of the various complications, their prevention and treatment.

ROUTINE TREATMENT DURING AN UNCOMPLICATED CONVALESCENCE FOLLOWING A MAJOR OPERATION UNDER GENERAL ANESTHESIA

Removal of the Patient from the Operating Room to Bed.—Upon leaving the operating room, the patient is swathed in warm blankets and the head is kept to one side to facilitate the escape of vomitus and so prevent its aspiration.

Removal of a heavy patient from the stretcher to his bed is a difficult matter when done in the usual manner, with attendants standing on both sides of the patient. Instead of this, the attendants should all stand on the same side, reach well under the patient, and all raise together, then walk to the bed and gently lower the patient into the proper position. The stretcher and bed should be placed end to end to facilitate this maneuver.

Position of the Patient in Bed.—Unless especially contra-indicated, the patient should lie flat on the back with the head turned to one side.

The head is not to be elevated until consciousness has been regained. Certain individuals, however, with very rounded shoulders, or short thick necks, do not breathe well if their heads are allowed to lie upon the mattress without support; for in such cases there is a hyperextension of the neck with consequent obstruction to respiration. A little experimenting quickly shows the exact elevation of the head

at which respiration is easiest in these cases. Hard, flat pillows are the best for this purpose.

The other positions, such as the Fowler position in abdominal conditions, the lowering of the head of the bed in shock, and the maintenance of the right-sided position in acute dilatation of the stomach, will be dealt with in discussing these subjects later on. But, no matter what the position is, care must be taken to vary slightly the typical position from time to time, to avoid formation of a decubitus.

Before leaving the subject of positions, it may be remarked that not enough attention has been given to the elevation of limbs by suspension rather than by support with pillows.

Maintaining the Temperature of the Body.—As soon as the patient is properly placed in bed, he is covered with warm blankets, and if the clothes are soaked with perspiration, they are changed for dry ones. **The possibility of burning the unconscious patient with hot-water bottles must never be forgotten.**

Operating tables having arrangements for being kept warm are like permanent baths—theoretically good, practically bad. I know of at least 1 damage suit brought by a patient burned by this device—not by the hot-water bags.

Emergence from the Anesthetic.—The color is good, but the breathing is much shallower than while the anesthetic was being pushed. It is important to remember that the pulse *always* becomes smaller for a short while after the anesthetic (ether) has been stopped, and that its quality gradually improves as consciousness is regained.

Administration of Water.—As soon as the patient is brought to bed, one of the standard methods for administration of water should be employed without waiting for consciousness to be regained. The best and most rapid way of combating the after-effects of a general anesthesia—headache, nausea, and thirst—is to furnish the body plenty of fluid. There are various methods available, the "Murphy drip," a simple enema (1 pt.) of plain water, subcutaneous infusion,[1] and intravenous infusion—this last only in cases of shock or hemorrhage. The details of these methods will be given later.

Postoperative Vomiting. Vomiting frequently heralds the awakening of the patient from the anesthesia. In case of vomiting while the patient is still unconscious, the head should be turned to one side to permit ready escape of vomitus and minimize the chances of aspiration. If the patient can swallow, there is little likelihood of his aspirating vomitus. For methods of using mouth gags, pulling the lower jaw forward, etc., see Vol. I, Chap. III.

Postoperative Pain.—As soon as the patient shows unmistakable signs of returning to consciousness and of suffering pain, he should receive an injection of morphin ($\frac{1}{8}$ gr. for an adult). As a rule, this need not be repeated. Under the influence of the morphin, especially if the room is darkened, sleep comes on in a short time.

---

[1] After every lengthy operation Reichel, for many years past, has injected 1,000 to 1,500 c.c. of normal saline subcutaneously before consciousness was regained.

If the patient complains of pain in a given locality, make sure that everything is as it should be, before advising him to bear his sufferings with fortitude. Perhaps a binder or bandage or a cast is too tight at some one spot, or the rectum or bladder may require emptying.

Restraint of the Patient. Restraining sheets extend from side to side of the bed and from under the arm pits to below the knees. If necessary, the wrists should be tethered to the sides of the bed with thick gauze bands (so as not to cut). This is especially important when there is a tendency to thrust the arms under the restraining sheet or to disturb dressings about the head or neck.

Postoperative Thirst. Nothing is given by mouth until vomiting has ceased for several hours. (If the vomiting persists more than a few times immediately following return to consciousness, the stomach is washed out.) Fluids, such as tea or water with a little lemon juice, may be given in small quantities as hot as can be borne. Hot fluids do not lead to nausea. As time goes on, and there is no return of vomiting, the amount of fluid is increased.

Care of the Bladder and Bowels. Urine is passed within a few hours after awakening. The bowels are moved on the second day by a low enema or a mild laxative. There is often no need for cathartics, if one can manage with enemata supplemented by a suitable diet.

Nourishment. By the end of 24 hours the worst of the pain and discomfort will be over. Proctoclysis has been stopped. Fluids, with the exception of milk,[1] should constitute the chief nourishment until the third or fourth day, when soft diet is commenced; full diet is started on the fifth, sixth, or seventh days.

Temperature. The usual postoperative rise in temperature subsides within 24 to 48 hours, after which the temperature remains normal.

Care of the Operative Wound. In clean cases, the wound is dressed on the fifth, sixth, or seventh day, according to circumstances. The stitches are then removed and a dry dressing is applied to stay on for a week more; usually at the end of this time no further dressing is necessary.

Sitting Up, Walking, etc. The time when the patient is to sit up in bed, and when he is to walk, is determined by many factors, such as the nature and extent of the operation, the locality operated upon, and the general condition of the patient. For example, after breast amputations or thyroidectomy for simple goiter, patients are up, out of bed, on the second or third day, while after laparotomy the average time is 14 days, with variations from 7 to 21 or even 28 days, according to circumstances.

When the patient is ready to go home, he should be instructed regarding diet, its effect upon the large intestine, the proper care of the wound, especially the necessity of shielding it from too much strain, and the necessity of medical examination at suitable intervals.

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[1] It is not good to give milk until the alimentary tract is fit to receive solid food, as it readily ferments and leads to gastric stagnation and dilatation.

Most conscious patients move about a little of their own accord, but I once saw a Slavonian peasant woman who failed to do so, and who consequently developed a bed sore over the coccyx 48 hours after a perineorrhaphy.

POSTOPERATIVE SHOCK

RECOGNITION OF SHOCK

General Symptoms.—The essential symptoms of traumatic shock are as follows:

1. General profound apathy. The patient lies perfectly quiet and pays no attention to his surroundings. Only after repeated, urgent questioning is there any answer.
2. Reduced sensibility—only slight reaction to very painful impressions.
3. Extreme motor weakness. There are no spontaneous movements of any sort, and only on repeated and urgent requests are brief, limited movements made with the extremities. When the limbs are lifted passively and then let go, they fall as though dead.
4. Extreme pallor. The skin and visible mucous membranes have a marble-like pallor.
5. A clammy sweat.
6. Pupils dilated and reacting sluggishly to light.
7. A weary, indifferent expression.
8. Very rapid and small pulse.
9. Respirations long and abnormally deep, varied with rapid superficial ones.
10. Temperature subnormal.

Surgical shock is that which develops in the course of an operation or soon afterward. The symptoms of surgical shock develop more slowly than those of traumatic shock, and their outlines are often obscured by the pathologic state preceding the operation, the effects of the anesthetic, and possible hemorrhage.

In postoperative cases, unless one knows the details of the operation, it is frequently impossible to differentiate between the symptoms of shock and those of hemorrhage. Knowing, however, what has gone on, the diagnosis can, as a rule, be made without difficulty.

It is easier to differentiate the symptoms of shock from those of hemorrhage at their beginning than later on, when they become practically identical. The chief points of difference are:

1. Mental state: Depressed in shock; stimulated in hemorrhage (the patient is wide awake, conscious, restless, and anxious).
2. Muscular tone: Absent in shock; accentuated early in hemorrhage.

3. **Skin:** Cold and clammy in shock; pallid and dry in hemorrhage.

4. **Respiration:** Rapid, shallow, irregular—Cheyne-Stokes type—in shock; rapid and at times deep, with distinct air-hunger, in hemorrhage.

5. **Pulse:** Rapid, irregular, and weak in shock; a steadily progressing increase in rate, with a proportionate decrease in quality, in hemorrhage. This may be obscured by the after-effects of anesthesia (the pulse always weakens after the narcosis has stopped and while the patient is awakening).

The Determination of Blood-pressure.—The simplest and most accurate method of determining the blood-pressure is by auscultation. This method was devised by Karokow in 1905. By means of it, the diastolic as well as the systolic pressures can be determined with far greater certainty than by visual reading of an aneroid needle or a mercury column.

The following excerpts are taken from Nicholson (6). Figure 1 shows Nicholson's pocket sphygmomanometer being used in conjunction with the auscultation method.

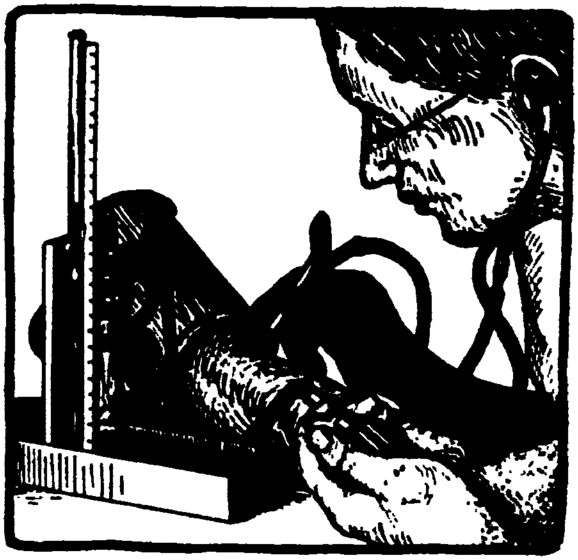

FIG. 1.—AUSCULTATORY METHOD FOR DETERMINING BLOOD-PRESSURE. (After Nicholson.)

"After one has applied the cuff of the blood pressure apparatus to the patient's arm and inflated it until all pulsation below the cuff is obliterated, then by releasing the air pressure slowly and listening with an ordinary binaural stethoscope over the artery below the line of the cuff, one hears a loud clear thump when the arterial wave first passes the constricting cuff. The height of the mercury column read at this moment indicates accurately the systolic pressure. If one continues to listen over the artery and to release slowly the air pressure, the first thumping sound is replaced by a murmur which, in turn, is followed by a second thumping sound which gradually becomes louder, then fainter, and shortly thereafter disappears. . . .

"The true accurate diastolic reading should be made at the time the second thumping sound is loudest. It is, however, much easier in most cases to determine the time of disappearance of all sounds, which gives a reading approximately 3 to 5 mm. lower. For clinical purposes the disappearance of all sounds will suffice, with the exception of cases of aortic regurgitation, in children, in patients with widely dilated arteries, and in high pressure cases where the difference may amount to 8 to 16 mm. of mercury.[1]

"In small children the auscultation method of obtaining blood pressure readings is not applicable, as the arteries are so small that the sounds are not distinguishable, and in many cases, not audible."

[1] Louis N. Warfield, Jour. Am. Med. Assn., Oct 4, 1913.

The readings taken in the manner just described are more accurate than those taken by the method of compression gradually (the diastolic reading coming first, then the systolic). It is unnecessary to invest in any expensive apparatus. A machine provided with a U tube wide enough to allow the mercury to flow freely from one arm to the other, a millimeter scale, and a pneumatic cuff, has all the requisites.

As a rule, the fall in blood-pressure is a fairly accurate index of the degree of shock present. However, it is well to bear in mind that the symptoms of shock may appear in the presence of a relatively high blood-pressure; in other words, the onset of nervous symptoms occurs long before the cardiac and vascular breakdown. Consequently do not allow the clinical picture as a whole to escape you because of too close attention to the details of one of its components (the blood-pressure).

There is no accurate index of cardiac efficiency. The height of the systolic or diastolic columns, the pulse pressure, and its percentage of the systolic readings are of no value in determining the reserve force of the heart. The most accurate source of information is the patient's own statement regarding his capacity for exertion.

TREATMENT OF SHOCK

Preventive Measures

Choosing the Proper Time for Operation.—IN ACUTE INFECTIONS.—It is a matter of personal experience and judgment to decide whether matters are going from bad to worse, and, therefore, whether to operate immediately, before the patient's condition becomes any poorer, or whether to wait for possible improvement. Observation of a few hours often indicates the direction the illness is taking. As a rule, in young people, at the beginning of an attack, immediate operation gives the best results, while in old people, often there is more risk in operation than in skillful delay. Exceptions to this rule are numerous.

IN CHRONIC CONDITIONS.—The patient's resistance is often raised by a course of *preliminary preparation* instituted either for the sake of improving (1) the *general condition* by suitable hygienic measures or (2) the *local conditions* (for example, the preliminary treatment in prostatics or in patients with rectal stenoses).

Preventive Measures Immediately before Operation.—PRELIMINARY TRANSFUSION.—A preliminary transfusion is indicated in anemic individuals; for example, in the presence of a bleeding duodenal ulcer, a ruptured ectopic pregnancy, or an internal postoperative hemorrhage, as well as in cases of chronic anemia.

AVOIDING TOO DRASTIC MEASURES IN THE COURSE OF PREPARATION FOR OPERATION.—Do not exhaust the patient with a series of enemata, as, for example, preliminary to vaginal plastic operations; a dose of castor oil will evacuate the bowels and constipate them afterward- exactly what is desired.

AVOIDING FRIGHT IN THOSE HAVING A TENDENCY TO TACHYCARDIA. -- At the clinic of Crile, for a week before an operation for exophthalmic goiter, the patient is seminarcotized every day and is given the impression that this is part of the routine treatment of the disease. The tachycardia due to fear is not present at the daily, matter-of-fact induction of narcosis; and, unknown to the patient, the actual narcosis is started in bed just as on previous days.

Anesthesia. LOCAL ANESTHESIA. Local anesthesia is induced either by local infiltration of the tissues close to the wound, or by blocking of the nerves nearby, or at their exit from the spinal canal (paravertebral anesthesia), or within it (spinal anesthesia). Of these methods, nerve blocking is the safest and least likely to cause general intoxication from absorption of the anesthetic next in safety is local infiltration; most dangerous of all is spinal anesthesia one never can tell in which cases it will cause profound collapse and even death. While local anesthesia is most satisfactory in preventing shock in a large number of operations, there are certain fields in which, so far, it has not proved available; for example, in intrathoracic procedures, and in opening the bony wall of the skull.

Excitable patients are unfavorably affected by the sights and sounds of an operating room, even though they are not suffering pain.

Besides all this, its successful administration requires a certain amount of experience and a patient disposition. The loss of time (as compared to general anesthesia), while waiting for the anesthesia to set in, as well as the delay from attending to the increased oozing from the infiltrated tissues, will prevent its routine adoption in clinics where a large amount of work must be done in a given length of time; here, local anesthesia will be reserved for urgent operations upon those weakened by shock, hemorrhage, or senility.

Local anesthesia has a final disadvantage in that its after pain is very severe and often is much less susceptible to control by morphin than that after general narcosis.

GENERAL ANESTHESIA.- BY INHALATION.- The individual skill of the anesthetist plays a most important part in reducing to a minimum the harmful effects of a general narcosis. The services of a skilled anesthetist instead of a less skilled one, often decide the difference between life and death in critical cases.

Nitrous oxid-oxygen anesthesia is the least depressing of all the methods of inhalation narcosis. Many European operators, as well as a few Americans (notably Crile), reduce the amount of general anesthetic required by benumbing the subject with a dose of scopolamin and morphin (injected 1 hour before operation commences). Scopolamin is an extremely potent drug, its preparations vary in strength, and its safe administration requires special preliminary training, obtained preferably at the clinics where it is employed in large numbers of cases. It has the advantage that the patient's sensorium is so dulled before operation that he is completely indifferent to his surroundings when he comes into the operating room, and suffers no pain for several hours after, though some observers with an impartial turn of mind deny this beneficent effect upon the after-pain.

The advantages of nitrous oxid are that it does not reduce blood-pressure, it does not cause rapid respiration, and the after-effects are nil (the patient does not thrash about in a semi-unconscious, irrational state). On the other hand, it is expensive, and it does not afford as complete relaxation as ether or chloroform. This latter is especially important in performing laparotomy upon alcoholic subjects.

Ether.—In the hands of a skillful anesthetist, a person in average good general condition suffers no marked depreciation in strength from the administration of ether. In the aged or in the very ill, the dangers of its depressant effects are infinitely increased; in these cases it is safer to use local anesthesia.

It is usually impossible to discern those children who are subjects of so-called lymphaticus or those with congenitally narrowed aortæ. The diagnosis in these cases is usually established on the autopsy table.

Chloroform.—Chloroform administration requires much greater watchfulness and skill than ether; a few drops too much may kill the patient. It does not have so marked a preliminary stage of excitement as ether, nor is the awakening so disagreeable. Late chloroform poisoning, since its wider recognition, is recognized as occurring more frequently than was formerly supposed. (In cases of eclampsia, ether has superseded chloroform since it was ascertained that the latter aggravated the degenerative changes in the liver.) Nevertheless, chloroform is still of great convenience where a very brief narcosis is required for performing the critical part of an operation the most of which can be carried out under local anesthesia, for example, removal of a common duct stone in an enfeebled individual.

Ethyl chlorid is an extremely dangerous general anesthetic. I know of several deaths in out-patient work from this cause.

INTRAVENOUS NARCOSIS.—The employment of intravenous narcosis (5 per cent. ether in normal saline) is governed by the same indications mentioned for the use of local anesthesia, namely, in persons whose condition forbids a general narcosis, but who, nevertheless, require a life-saving operation. Within a few minutes, loss of consciousness sets in, there is no preliminary excitement (except in alcoholics, and here Kümmel uses a preliminary intravenous injection of "isopral" in saline solution), the breathing is not increased, and the patient sleeps quietly. The after-effects are said to be less than those following inhalation narcosis. Prolonged intravenous anesthesia causes a troublesome (to the operator) hydremia of the tissues. With proper precautions, the danger of thrombus formation at the site of injection and the occurrence of embolism is negligible according to the advocates of this method.

RECTAL NARCOSIS.—Rectal narcosis (by a 33⅓ per cent. ether in oil solution) is mentioned only to be condemned as too uncertain and too dangerous.

While in many cases the effect is as satisfactory and the patient is as quiet as under intravenous narcosis, in others, the narcosis becomes dangerously deep; in these cases the anesthetist may empty the colon of its oil-ether mixture, but after this act he is practically helpless to counteract the effect of the absorbed ether. The method is to be avoided because of the difficulty in estimating and controlling the effect of the narcotic.

Differential Pressure. It is a well-established fact that operations under differential pressure, if continued for any length of time, leave the patient in shock. Many operators have observed this and, independently of one another, have devised ways of avoiding it; some maintained intermittent artificial respiratory movements, others temporarily closed the chest wall as soon as the first signs of circulatory disturbance appeared, and only renewed operation after the pulse had improved. It remained for Janeway and Ewing to establish the fact that the cause of shock was the long-continued mechanical interference with the return of the blood to the heart (not only the return from the systemic circulation but also the return from the pulmonary veins, especially in the capillaries and veins within the lungs themselves).

Henderson's theory of acapnia, adopted from Mosso, has awakened much interest of late.

Observed Fact. Shock of respiratory origin. Rapid voluntary breathing, the rapid breathing caused by pain, rapid artificial hyperrespiration, the production of acapnia by the Brauer-Sauerbruch, or the Meltzer-Auer differential pressure methods, all produce shock sooner or later.

Interpretation. Yandell Henderson has suggested that, since the rapid breathing reduces the amount of carbon dioxid in the blood to such a degree that there is not enough CO_2 to stimulate the respiratory center (the respiratory center has been proven to be uninfluenced by the amount of oxygen present in the blood; it is susceptible only to the varying amounts of CO_2), breathing, therefore, ceases (acapnia) for a varying length of time, during which no fresh supply of oxygen reaches the tissues; death from lack of oxygen may come on before sufficient CO_2 has accumulated to start respiration again. Janeway and Ewing, on the other hand, have demonstrated that just as severe a degree of shock may be produced by artificial hyperrespiration, when provision is made for keeping the carbon dioxid content of the blood high, as when it is allowed to fall to 40 per cent. or 50 per cent. of the normal.

Prevention of Shock at Operation.—DURATION OF PROCEDURE.—The shorter the time a patient is on the operating table, the less shocked he will be, all things being equal. Recognition of this has led to the development of *the "2-stage" principle*; for example, in craniotomy for brain tumor, the soft parts and skull are opened, exposing the dura, and the wound is then closed; the secondary operation (at times done under local anesthesia) consists in re-opening the wound, opening the dura, and proceeding to explore the brain without further delay. Other examples are seen in resection of the pylorus a few weeks after establishing gastro-enterostomy; the removal of the prostate secondary to establishment of a suprapubic cystotomy, and the 2-stage operation for carcinoma of the rectum.

AVOIDANCE OF UNNECESSARY TRAUMA.—The fall in blood-pressure caused by handling intrathoracic or intra-abdominal viscera is directly proportionate to the amount of force employed, as repeatedly proven experimentally; hence, the shorter the period of trauma (operation) and the less the degree of trauma inflicted (the more gentle all manipulations are), the less shock will there be.

HEMOSTASIS.—The susceptibility of a patient to the effect of shock-producing agents is directly in proportion to the amount of blood lost.

BLOCKING OF LARGE NERVE TRUNKS.—Blocking of large nerve trunks before division, with local anesthesia, and blocking of the splanchnic plexuses before operations in the areas of their distribution are conceded to be of great value even by those who differ from Crile in both theory and experimental findings.

Crile holds that shock is due to the overexhaustion of the nerve centers by overstimulation. Porter, confirmed by Janeway and Ewing, found that long-continued stimulation of afferent nerves caused a rise, not a fall, in blood-pressure; that this rise was as evident at the end of the experiment as at the beginning; moreover, Porter found that stimulation of the depressor nerve, even in shock, reduced the blood-pressure 45 per cent.; he therefore maintained that the vasomotor cells were neither exhausted, depressed, nor inhibited; that there was no exhaustion of the nerve centers. Speaking of blocking of the sensory nerves during operation under general anesthesia, Janeway and Ewing say: "It is doubtless a wise precaution, on account of the more complicated manner in which reflexes may be modified in human beings than in animals. . . . Such blocking will often spare a patient reflexes which may seriously lower the blood pressure. But the harmful effect (from trauma), if it persists, is not due to fatigue of the nerve centers, but entirely to reflexes and peripheral changes (paralysis of the gut from handling, for example) which may be either secondary to them, or the result of other local peripheral causes, or both. It is important to recognize that vasomotor control may be impaired or lost by peripheral injury alone. The central mechanism seems capable of outlasting the peripheral mechanism every time."

Meltzer believes that the attention accorded to the fall in blood-pressure has led to underestimation of the inhibitory powers of the nervous system. According to him, inhibition (following trauma) causes secondary changes which in turn lead to irreparable damage.

For other opinions, see chapter on Anesthesia (Vol. I, Chap. III).

CONSERVING THE BODY WARMTH is so much a matter of course that it requires no further mention.

Therapeutic Measures

There is almost no field in which so little has been done as here. We know very little about the actual effect of the drugs commonly employed in the routine treatment of shock. The generally accepted idea is that if the patient rallies, it is due to the stimulation; if he dies, it is because he "failed to respond" to stimulation. Yet in olden times it was often observed that patients having no ascertainable external injury as the result of falls or blows, yet apparently moribund, would, if left to themselves, be "restored to the tone and tranquillity of normal health by the next day." [1]

As said elsewhere, it is practically impossible in many instances, to distinguish between postoperative shock and hemorrhage, especially after long, severe operations. In case hemorrhage is present, the stimulation administered on account of the supposed shock, instead of helping the patient, merely hastens his end.

In far gone cases of shock or hemorrhage, although transfusion of blood or infusion of salt solution is followed by temporary improvement, this passes off within a few hours, and even if the attempts at stimulation are renewed, the patient fails to respond. One therefore must not be too sanguine because of temporary improvement but must keep the patient under close observation until assured that he is really out of danger.

Position.—The patient is to be kept on his back, the chest free from encumbrance, the head flat, and the foot of the bed raised at least 18 to 24 in. This insures the assistance of gravity in favoring blood supply to the brain. The patient frequently tends to slide up and jam his head against the upper end of the bed. This is prevented by passing a sheet over the shoulders and fastening it to the bed near its foot.

To furnish all the blood possible to the heart for maintaining the viability of the vital centers, constrictors are applied to the extremities, the limb being held upright for a few moments before applying the constrictor. (For details in technic, see Constriction, under Mechanical Control of Hemorrhage.) As a rule, 2 extremities are tied off at a time for from 15 minutes to 1/2 hour, there being less tendency to reactive hyperemia after short periods of constriction. Pressure upon the abdomen also tends to express the stagnating blood in the splanchnic area into circulation, but the pressure must not be so applied that it hinders respiratory movements.

Warmth.—Warmth is maintained in the usual manner by hot blankets and hot-water bottles. Regarding the latter, it should be remembered that often the patient is not in a condition to complain, and severe burns may be unwittingly inflicted. It is, therefore, safer to wrap the bottles in flannel.

Fluids.—TRANSFUSION. Transfusion is the sovereign remedy. It is essential to make preliminary serological tests for determining the agglutinative and hemolytic action of the recipient's serum on the donor's cells and to ascertain that the donor's Wassermann reaction is negative. In cases of emergency, where blood tests cannot be made, the patient's nearest available blood relative will suffice.

Having selected a suitable donor the transfusion may be effected either directly or indirectly.

DIRECT TRANSFUSION.—In direct transfusion the vein or artery of the donor is united to the vein of the recipient. This is accomplished by direct suture after the technic of Carrel or by means of some intervening cannula of the Crile,

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[1] Travers after Meltzer.

Elsberg or Bernheim pattern. In all of these, intima comes into contact with intima, and the tendency to thrombus formation is reduced to a minimum.

With the direct method, an ingenious means of estimating the amount of blood carried over has recently been published by Libman and Ottenberg (4).

INDIRECT TRANSFUSION.—The most ardent advocate of this method is Lindeman, who uses a series of "Record" syringes. His method in detail is described in Vol. I, Chap. VIII. Of all methods, this is the simplest, and, once the veins have been entered, requires least skill. It has the advantage that the exact amount of blood transfused is known.

INTRAVENOUS SALINE INFUSION.—Intravenous saline infusion is the injection of a solution containing 8.5 gm. sodium chlorid to 1 liter of freshly distilled sterile water. (Recently the intravenous use of sodium bicarbonate has been recommended in conditions of shock.) The solution in the container should be kept at 110° F. The most rapid and convenient way is to apply a constrictor to the arm close to the shoulder, and disinfect the skin at the bend of the elbow; by this time the veins are well distended and there should be no difficulty in thrusting a hollow needle through the skin into the lumen of a vein. As soon as blood flows from the needle the tubing leading to the container is connected with the needle, permitting the saline solution to enter the blood stream. (Care must be taken that no air bubbles are carried in; some of the solution should be allowed to escape before making the connection and, as the connection is being made, blood should be freely running from the needle and saline from the tube.) The constrictor is then released. The fluid is allowed to run in slowly so as not to overdistend the (already weakened) right heart. The pressure and rate of flow are regulated by raising or lowering the flask container. The usual quantity is 500 c. c. introduced in the course of 10 minutes. This may be repeated in 2 hours.

In case the veins are collapsed, they are readily exposed by a small *transverse* incision made at the bend of the elbow; then, by means of a traction ligature, the vein is pulled taut, is nicked laterally, and through this opening a cannula's point is inserted. Upon withdrawal of the cannula, the vein is ligated just above and below the site of insertion. The skin is closed and a dry dressing is applied. In unskilled hands this way is longer but surer. It cannot be used very often, because within a short time, all of the accessible superficial veins are out of commission.

It is frequently convenient to introduce medication with the saline. To do this, the needle of a hypodermic syringe, containing the required dose, is thrust through the wall of the rubber tubing, and the syringe is slowly emptied (see Medication).

ENTEROCLYSIS AND HYPODERMOCLYSIS are described under Administration of Water, page 29.

STIMULATING ENEMATA of hot coffee, 8 oz., or hot water and whiskey, 2 oz. each, are of value (see Medication).

Medication.—MORPHIN.—Morphin relieves the pain, thereby quiets the patient, and thus conserves the body's energy. By lessening the pain from local trauma, it lessens harmful reflexes of inhibitory effect, etc. If technically possible, local anesthesia should be used, but this will not be often. While opiates are generally contra-indicated in children, in the aged, and in those with impaired kidneys, the contra-indications are not absolute in the presence of severe forms of shock and hemorrhage. As a matter of course, if there is unconsciousness, there is no need for opiates.

STROPHANTHIN. This is a solution of the chemically active substance ouabain (pronounced wah-ba-ine) derived from strophanthus. It is one of the most effective stimulants we have, because in the crystalline form [1] it is constant in purity, strength and action. Its pharmacology has recently been placed upon a firm basis by Hatcher. It has an immediate effect upon the heart's action and causes an increase in blood pressure. It is given intravenously in doses of 1 mg., which may be repeated every 6 hours, from 3 to 4 times. It is now conveniently marketed in ampules each containing 1 mg.

ADRENALIN. Adrenalin is a stimulant to the nerve endings of the vasoconstrictors and immediately causes a maximum spasm of all of the peripheral arterioles. While giving the intravenous infusion, it is often convenient to inject 15 minims of adrenalin chlorid, 1 : 1,000, directly into the rubber tubing. This is introduced slowly so as to be distributed throughout 200 to 400 c. c. It is not so effective subcutaneously. The chief drawback to the drug is its fleeting action; its value lies in its immediate effect; hence it may be used until something more lasting is being absorbed.

CAMPHOR. Considerable controversy has recently arisen as to the effectiveness of this drug. Clinically there apparently is no doubt of its value. It may be given at the time of the primary symptoms of collapse and continued at intervals throughout the treatment. The solution in ether gives a quicker response than that in oil. The dose is 5 gr. repeated if necessary. Camphor in ether must be injected deeply into the tissue to avoid local necrosis of the skin. Conscious patients should not receive it on account of the pain it causes. Repeated doses of camphor often cause delirium (accumulation).

CAFFEIN.—Caffein merely increases the heart's rate and thus diminishes the reserve cardiac power. Remember that the drug is a cerebral stimulant; it may prevent the patient from getting much needed sleep. The dose is 5 gr. Caffein poisoning is not at all unusual after long-continued administration.

ATROPIN.—This drug is a specific stimulant of the respiratory center. Its circulatory action is not desirable, as it increases the cardiac rate and wears out the reserve power. It is, however, of value in cyanosis with difficult respiration; moreover, in combination with morphin, which is a respiratory center depressant, it is valuable. The dose is gr. 1/100.

DIGITALIS.—This is the cardiac stimulant par excellence, but, because of the long latent period (24 to 48 hours), it is not available in the emergencies of shock and hemorrhage. It is of especial use in the convalescence from a severe shock, where it takes several weeks for the circulatory system to regain its balance. The preparation of constant strength and effectiveness is the tincture, which may be given in doses of ♏xxx every 4 hours for 3 or 4 days and then stopped for 2 days and the process repeated.

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[1] The amorphous form is unreliable because of its varying strength; usually, weight for weight, it is distinctly less potent than the crystalline form, sometimes 50 per cent. less.

Another reliable preparation is "digipuratum"; given intravenously (it comes in ampules containing ½-gr. doses) it begins to have effect at the end of 2 hours; given by mouth in ½- and 1½-gr. tablets, no effect can be expected before the end of 12 to 24 hours.

ALCOHOL. Opinions differ regarding the value of alcohol. Hot stimulating enemata consisting of saline ℥ii and whiskey ℥ii, repeated every 4 hours, are frequently used.

PITUITRIN.—This substance has been introduced so recently that its value in shock is an unknown quantity. It is a smooth muscle stimulant. The various pituitary extracts on the market differ widely in potency and toxicity. One c. c. of posterior lobe extract hypodermatically, every 6 hours, is the dose.

STRYCHNIN.—This drug is mentioned merely to be condemned. Experimentally it has been proven to be an accelerator of the spinal reflexes and **not a true stimulant.** Because it helps to further the distribution of noxious afferent impulses, it is highly undesirable. Clinically these facts have been repeatedly demonstrated.

REDUCTION OF STIMULATION.—When a patient is placed upon active stimulation, his system comes to depend upon the artificial prop to a greater or less extent. Removal of all of the stimulants at 1 time invites collapse. It is wise, therefore, gradually to reduce the stimulation by slowly eliminating one drug after another and lengthening the intervals of administration.

The appended lists of nurse's orders may be convenient to follow:

Moderate Shock.

1. Shock position (foot of bed raised 18 inches).
2. Hot blankets.
3. Stimulating enemata, whiskey ℥ii, saline ℥ii, at 120°, Stat.
4. Magendie sol. ♏vi. } When the patient shows signs of returning con-
   Atropin gr. 1/100. } sciousness.
5. Enteroclysis, tap water, 2 hours on and 2 hours off.
6. Camphor gr. v. } Alternate every 4 hours, which means that one is
   Caffein gr. v. } given every 2 hours.

Severe Shock.

1. Shock position 24 in.
2. Saline infusion 500 c. c. or bicarbonate infusion. Adrenalin ♏xv into tube.
3. Strophanthin, 1 mg., intravenously.
4. Hot blankets and hot-water bottles.
5. Stimulating enema, whiskey ℥ii, saline ℥ii, at 120°.

6. Caffein gr. v. } Alternating every 2 hours.
Camphor gr. v.
7. Hypodermoclysis 500 c. c. every 8 hours.

Extreme Shock.

Transfusion in addition to the above.

POSTOPERATIVE HEMORRHAGE

GENERAL CONSIDERATIONS

Hemorrhage may be divided into 2 varieties:

(1) Primary, at the time of operation.

(2) Secondary, after operation. By reactionary hemorrhage is meant that coming on within 24 hours after operation.

Primary Hemorrhage. Primary hemorrhage, in the vast majority of instances, is controlled as soon as it occurs. More rarely it fails to be noticed and continues unknown to the operator. Lack of proper exposure, haste, and carelessness are prime factors in the production of this disaster—disaster, because by the time the true condition of affairs is discovered, the patient is usually exsanguinated and moribund. Laparotomies in very fat people, extirpations of the rectum, and vaginal hysterectomies performed by men of limited talent and experience for the second or third time are especially prone to this accident. The first time the tyro is careful, and if he has the luck to escape trouble, a false idea of his own capacity may render him overconfident and careless.

Reactionary Hemorrhage. Reactionary hemorrhage is frequently due to the displacement of a thrombus in the mouth of a vessel or to the slipping of a loosely tied ligature. The sudden rise in blood-pressure and the increased muscular strain which accompany vomiting are potent factors in its production.

Do not mistake the profuse discharge of blood stained serum for actual oozing. Compare the color of the patient's lips with the color of the stained gauze. Naturally this contrast will be more marked in patients whose hemoglobin is high than in those who are anemic.

Oozing is very apt to follow operations upon the neck, resection of joints, amputations, etc. Elevation and compression usually control it. If possible, do not disturb the drainage of the wound or the gauze lying immediately in contact with it. Individual circumstances will determine whether it is better to exchange the blood-soaked superficial parts of the dressing for fresh dry dressings, or to leave the original dressing alone, placing upon it additional fresh dry gauze.

The limb distal to the site of operation (if there has been a resection) should be encased in a firm supporting bandage. It is well to make sure that the part of the bandage proximal to the field of operation is not so tight as to obstruct the venous return, thereby increasing the tendency to oozing. Additional compression to the oozing area may be obtained by means of a small hard cushion or sand-bag and a rubber bandage. Naturally too much compression must not be employed for fear of interfering with circulation of the limb.

If the hemorrhage is plentiful and of an arterial character, and is not amenable to the above-mentioned elevation and compression, it is imperative to re-open the wound, and to expose and tie the bleeding point. In the extremities a tourniquet will control bleeding until its source has been exposed. In the trunk, local compression should be kept up until the very last moment before exposure.

Remember that no operation is so prone to be followed by infection as that for the control of secondary hemorrhage. This, in all probability, is due to the hurry and excitement of the moment, which allows breaks in aseptic technic to slip by unnoticed. The surgeon should bear in mind that the sterile gloves with which he removes the superficial dressings are contaminated and must be changed for fresh ones. This change of gloves should be accompanied by fresh drapings and the application of plenty of iodin.

For further details see Treatment of Hemorrhage in this chapter; also Postoperative Operations in the next.

Secondary Hemorrhage.—Secondary hemorrhage usually occurs in infected wounds (the degree of infection seems to have no especial influence in the matter), the clot occluding the mouth of a divided vessel becoming liquefied some time between the sixth and the tenth days. In pre-antiseptic times, secondary hemorrhage was so common that every surgeon was familiar with this complication. Now it is so rare that the methods of its control seem in danger of being forgotten.

Secondary hemorrhages often come from pressure of a drainage tube or a fragment of bone against the wall of a large vessel. This is more frequent in the neck (drainage of a retropharyngeal abscess with the drainage tube lying against the vessels) and in the extremities than in the trunk (for this see Drainage in Appendicitis).

In late secondary hemorrhages, small premonitory hemorrhages often precede the occurrence of severe hemorrhage from large vessels. Warned by these, the surgeon should keep the limb absolutely quiet and elevated, and, if possible, not disturb the dressings. A tourniquet should be loosely placed around the limb as close to the trunk as possible, to be instantly available in case of necessity. If, in spite of these precautions, hemorrhages recur, it is safer to open the wound and ligate the bleeding point rather than to run any further risk. The individual exigencies of the case will indicate whether it is better to ligate the artery in the wound, or above, in the position of choice.

THE NURSE'S DUTIES

An alert, intelligent nurse who recognizes that hemorrhage is going on, is so important a factor in preventing a fatal outcome that an outline of her duty deserves consideration. The nurse should notify the surgeon at once without alarming the patient, since fear, by raising the blood-pressure and increasing the pulse-rate, increases the bleeding. The various measures she should take after notifying the surgeon and pending his arrival may be considered under 3 heads:

(1) **Care of the Patient.**—*When the hemorrhage is from an extremity,* firm compression over the wound may suffice; if not, a tourniquet should be applied.

When there is hemorrhage from the trunk, its control, previous to the surgeon's arrival, is uncertain and difficult. Compression should be made, although its efficacy cannot be determined; a sand-bag (5 to 10 lbs.) held in place by a binder is good. (The Momburg tourniquet will be mentioned shortly. See Control of Hemorrhage.) Elevation lessens bleeding. The application of this principle, however, is easier with the extremities than with the trunk.

The patient, who is lying flat, is kept warm and quiet. To improve and maintain the cerebral circulation the head is kept low; this is accomplished most easily by raising the foot of the bed. Sedatives lessen uneasiness and apprehension. Under no circumstances is there to be any stimulation until hemorrhage is under control.

(2) **Preparation for Operation.** In order to lose no time, everything must be provided for a rapid operation. In a hospital, the staff attend to this. In a private house, the nurse in charge must do what she can. In case the instruments were not removed from the house at the time of the primary operation, they should be boiled; if they were, water should be kept boiling for their sterilization upon the surgeon's arrival. Ligatures, gauze, gowns and gloves must all be provided anew. In the city, these can easily be obtained; in the country one must improvise. Strong silk or linen thread makes excellent ligature or suture material. If no dry sterile cloths are available, everything should be put into a large wash boiler and the water drained off after boiling so as to permit of more rapid cooling.

(3) **Preparation for Stimulation.**—The necessary equipment for intravenous infusion or transfusion must be ready, with the solution at the proper temperature. The materials for a stimulating enema must be at hand; also, the customary hypodermatic stimulants. (See Treatment of Shock.)

Upon the arrival of the surgeon, the nurse's direct responsibility ends.

OTHER PRELIMINARY MEASURES

A transfusion before operating increases the patient's chances of recovery to such a degree that it should invariably be done (if a donor is available) in every severe hemorrhage.

Without losing any time, the wound must then be opened and the site of bleeding found and controlled. Undue hurry is sure to cause confusion and carelessness. I repeat that this is why infection follows secondary operations for hemorrhage so frequently. It is during the hasty removal of dressings, sterilization of the skin, and

draping, that the operator and his assistants, who are surgically clean, are very apt to infect themselves inadvertently.

The actual operative measures are dealt with in the chapter on Postoperative Operations.

Simultaneously with the operation, the preparations for the intravenous infusion are begun by some one especially designated for this purpose, so that the infusion can be started the instant the bleeding is controlled. Bear in mind that in very exsanguinated patients (as pointed out by J. A. Blake), too much fluid will kill by diluting the blood to such a degree that it cannot carry enough oxygen to the tissues for the maintenance of life. Transfusion is, of course, the ideal treatment under these circumstances; unfortunately it is less available than intravenous infusion.

HEMORRHAGE FROM THE ALIMENTARY TRACT

Hemorrhage from the alimentary tract following any major operation is an extremely serious complication. In some cases it originates from a latent gastroduodenal ulcer; in others from small erosions in this region; in still others there is a general oozing from the mucosa. The actual cause of the last is not known; most theories include the idea of an acute toxemia. The researches of Rosenau would indicate the possibility of a transient bacteriemia of organisms having a special affinity for the gastro-intestinal mucous membrane. Transfusion may be of distinct service in controlling parenchymatous oozing; it should precede any operation for finding the bleeding point whenever there is much anemia. Rovsing's method of gastrodiaphanoscopy is described in Postoperative Operations; briefly it consists in exposing the stomach by laparotomy, introducing a cystoscope through a minute and air-tight opening, inflating the stomach, and turning on the light, thus rendering the stomach translucent. If a vessel of the anterior stomach wall is seen to end abruptly, instead of tapering off, the point where it ends indicates the site of hemorrhage, which is then controlled by a simple hemostatic suture. If no such point is discovered, then, through the ocular of the cystoscope, the interior of the inflated stomach is scrutinized and the bleeding point is located (Rovsing reports having seen the blood issuing from the duodenum through the pylorus into the stomach). Some surgeons open the stomach widely and, after wiping it out, search for the point of hemorrhage.

With the various methods for performing transfusion with ease, speed and certainty at our disposal, the situation of the patient is by no means as desperate as in former years, and the operations just described have increased chances for success. (See also section on Stomach, Chap. II, Vol. IV.)

TREATMENT OF HEMORRHAGE

Do nothing without a definite reason.

Mechanical Control

Temporary Methods.—COMPRESSION.—*Direct digital compression* of an accessible bleeding-point with the bare finger is the quickest way to check hemorrhage. Because of the danger of infection, it is only to be employed as a life-saving measure in great emergencies (wounds of large vessels) in which the hemorrhage cannot be controlled by other means.

Digital compression of an artery against a bone somewhere proximal to the point of hemorrhage, if anatomically feasible, will control matters until more permanent hemostatic measures can be made use of: for example, compression of the femoral artery against the horizontal ramus of the pubis in hemorrhage of the lower extremity, compression of the abdominal aorta against the lumbar spinal column in hemorrhage within the pelvis, compression of the axillary against the head of the humerus or the subclavian against the first rib in the upper extremity; finally compression of the carotid against the transverse process of the 6th cervical vertebra in the neck.

Compression is also employed to control venous and capillary oozing. (See below.)

POSITION. Elevation of a bleeding part greatly lessens the rate of hemorrhage, and bleeding often ceases of its own accord if an elevated position is maintained for a few minutes. Elevation of the limbs invariably precedes application of hemostatic constriction. For maintaining elevation, suspension is frequently more convenient than support by pillows.

CONSTRICTION. Constriction may be maintained for as long as 2 hours without impairing the vitality of the tissues. It is important to maintain just the right degree of constriction, that is, just sufficient to obliterate the arterial pressure; if more than this is employed, there is danger of ischemic contracture (see elsewhere in this chapter); if less, the arterial supply continues, the venous return being blocked, hemorrhage is aggravated instead of diminished.

TECHNIC. A solid rubber cord or band or a long piece of drainage tubing of large caliber may be used. The limb is held vertical for a few moments. Esmarch originally advised expression of all blood by application of an elastic bandage to the elevated limb from the periphery up to the point of proposed constriction. This refinement was subsequently found of no practical importance, simple elevation being sufficient. The skin is protected by a cuff of folded towel and the elastic constrictor is put on the stretch and applied a sufficient number of turns to obliterate the pulse distal to it. During this application the first 12 in. of the end used to begin the constriction have been held free; the 2 ends, still on the stretch, are now crossed, and a bit of bandage ties them together[1] (Fig. 2). (A heavy clamp may also be used. EDITOR.) As the ends are released, the rubber thickens and crowds against the bandage, thus preventing its slipping.

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[1] If a slip knot is used, pulling the loose end releases it (Dawbarn); the usual knot is so hard to untie that generally the bandage is cut and the rubber is accidentally cut, too.

A pneumatic tourniquet has recently come into general use in Germany. Its action is identical with that of the cuff of the usual blood-pressure apparatus. Its application disturbs the patient very little, and the degree of compression is exactly and easily controlled.

Upon release of constriction, there is a reactionary hyperemia of the tissues, which favors increased oozing; for this reason, some surgeons apply firm compression to the limb before casting loose the constrictor; the limb is kept elevated for some time afterward for the same reason.

Momburg's elastic tourniquet is of the greatest possible value in controlling hemorrhage below the waist line. The tourniquet is part of the regular outfit of the emergency bags of German maternity hospitals. It is included in the first aid kits, also.

The patient is placed in the Trendelenburg position. The end of a piece of soft rubber tubing, having the thickness of the index finger and a length of about 4 ft., is passed under the back of the patient to be grasped by the hand of an assistant who stands at the opposite side of the operating table. The tube is then stretched very strongly, and, thus stretched, is passed by the surgeon midway between the border of the ribs and the iliac crests across the abdomen to the other hand of the assistant, whose duty it is to maintain tension. The free end of the tube is now led back under the patient by the surgeon and is again put on the stretch; the assistant meanwhile gradually releases the bight of the stretched tubing, which now firmly encircles the waist. While this is being done, another assistant places a finger on the femoral artery to ascertain the moment of cessation of the pulse. Observing the same steps, 2, 3, or more turns of tubing are exactly superimposed until the femoral pulse disappears. In slim individuals 2 turns will suffice; in fat or muscular ones, as many as 6 may be necessary. As soon as the femoral pulse is suppressed, the ends of the tube are crossed and secured either by forceps or ligature. After this is done, constrictors are applied to the thighs below Poupart's ligaments and to the legs below the popliteal spaces. As soon as the operation is finished (and all the vessels secured by ligature), the rubber band encircling the waist is removed. Directly after this, the other rubber ligatures embracing the thighs and legs are untied, one by one. The object of this is the gradual extension of the scope of the circulation and the avoidance of too sudden demand upon the efficiency of the heart muscle. Heart failure has been known to fol-

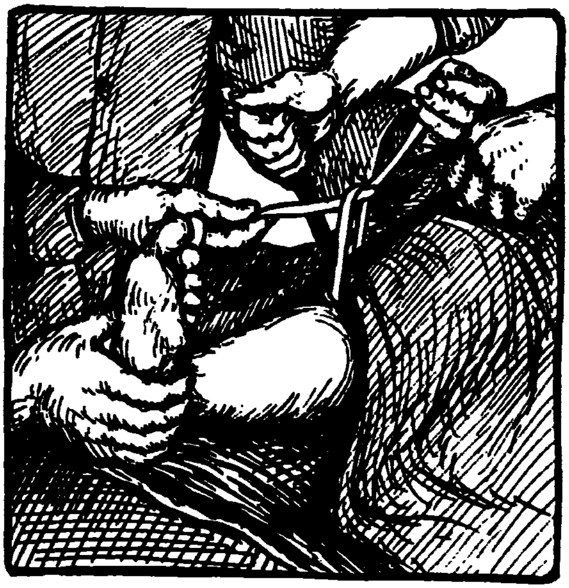

FIG. 2.—APPLICATION OF ELASTIC CONSTRICTOR.

low neglect of this precaution. By this switching on of one segment of the circulatory system after another, the re-adaptation of the heart to the changed conditions is gradually effected. The tourniquet has been safely applied for as long as 2 hours and 20 minutes.

The tourniquet has facilitated operations in and around the pelvis in the domain of general surgery (disarticulation at the hip-joint, extirpation of the rectum, interilio-abdominal amputation), in gynecology (abdominal and vaginal hysterectomies), and in the genito-urinary field (perineal and suprapubic prostatectomies). It may be added that the constrictor should be released before the closure of the wound is commenced, so that any bleeding points may be attended to; failure to observe this rule has led to several deaths from hemorrhage.

Permanent Methods. The operator must judge which one of the several procedures for obtaining permanent hemostasis enumerated below is most suitable under existing circumstances.

LIGATURE. If the hemostat fails to catch the bleeding point, do not release it, but hold it and use it as a handle to hold up the tissues this lessens the hemorrhage and makes it easier to catch the right spot with a second hemostat. In friable tissues the greatest gentleness must be used in tying vessels, otherwise the hemostat is torn loose or the ligature cuts through. Instead of pulling up on the ligature ends, run the tips of the index fingers down along them to the knot and then tighten gently, knuckles together. Make sure that the ligature has passed over the nose of the hemostat before releasing it. If a larger mass of tissue is to be tied off, the hemostat is removed while the operator maintains tension on the first knot; this insures the proper amount of constriction in cases where the hemostat holds the tissues in such a manner that they cannot be adequately compressed by the ligature and where, as soon as the clamp is taken off, the mass shrinks and the ligature may slip off.

HEMOSTATIC SUTURE. Hemostatic sutures should be passed on a round needle, and the ends left long after tying; if the bleeding has been stopped, they are cut short; if not, they form a convenient tractor which facilitates the placing of a second suture. Hemostatic sutures are useful in friable tissue and in the bleeding from dense fascial surfaces.

THE ACTUAL CAUTERY. The actual cautery is especially valuable in checking small persistently bleeding arteries in the mouth, pharynx and cervix. The cautery should be a dull cherry red, and must be constantly and gently moved to and fro to prevent attachment of the eschar to its point rather than to the bleeding spot. The cautery is useful in opening lung abscesses (secondary stage), opening colostomies (secondary stage), and in the secondary hemorrhages in the regions of the rectum and vagina.

CLAMPS LEFT IN SITU. This procedure is often resorted to when large vessels which must be divided are surrounded by a mass of infiltrated tissue and are so inaccessible (as in removal of a suppurating kidney) that the employment of a ligature is extremely hazardous (if the ligature slips off or cuts through, the patient may bleed to death before the vessel can be controlled again). The clamps are left in place for from 2 to 4 days.

At the Mayo Clinic, when a clamp is to be removed—usually at the end of 48 hours—it is simply opened without being displaced. Should bleeding occur, the clamp is closed again. The chances of catching the bleeding point are better by this than by any other method. If no bleeding ensues, the opened clamp is gently removed at the end of 12 hours.

Instead of a clamp, an elastic pedicle ligature may be used, which is tested thoroughly before applying. The crossed limbs are secured by a heavy silk thread, the ends of which are left long so that they lie upon the skin. At the end of 3 or 4 weeks, if the ligature has not come away of itself, the silk may be gently pulled upon.

CONTROL OF OOZING.- Elevation and the actual cautery have been spoken of above. Compression by gauze is another widely used method, especially convenient in hemorrhage from hollow organs, such as the rectum, bladder, and uterus. If there is moderate oozing from a superficial wound, it is only necessary to remove all of the gauze except the layer actually in contact with the wound, and then apply plenty of fresh gauze and a good, firm bandage or binder.

If wounds of the veins cannot be conveniently controlled by other methods, the hemorrhage will stop and they will heal after simple compression by gauze packings; this naturally entails the disadvantage of healing by granulation instead of by primary union (for example, injury of the lateral sinus in mastoid operations).

Adrenalin is frequently employed as a hemostatic after operations about the eye, ear, nose and throat.

In abdominal surgery, compression of oozing surfaces with flat pieces of fascia, muscle, fat and peritoneum has been used. The omentum, if accessible, is best for this purpose, because it does not undergo connective-tissue change and is least likely to give rise to dense adhesions.

In oozing from bone, especially in craniotomy, bone wax, softened and applied like putty, is of great convenience. If this is not available, crushing or gently hammering the adjacent bone into the mouth of the bleeding vessel will stop the hemorrhage.

For oozing from the brain, very hot saline irrigation, hot, wet cotton swabs, and bits of muscle tissue (taken from the adjacent temporalis) are all efficacious.

For controlling arterial hemorrhage in inaccessible localities, Harvey Cushing uses small silver clips left in situ. Extract of lung tissue is the most potent local hemostatic we have. In America it is called "Thrombokinase," in Europe "Coagulin-Kocher-Fonio." It must be applied directly to the mouths of the bleeding vessels; it is used by Kocher in parenchymatous oozing during goiter operations and is finding widespread adoption in this country. It is said to be expensive, and I am unable to state how long it keeps without spoiling.

The oozing of hemophilines is best controlled by subcutaneous or intravenous administration of normal (horse or rabbit) serum or human blood (see section on Bile Passages).

WOUNDS OF LARGE VESSELS. In cases where formerly ligation was the only way out of the difficulty, we are now able to repair the damage by means of the Carrel suture. If the necessary armamentarium is not at hand, in the case of an arterial wound, ligation will have to be done; with *veins*, because of their more flexible walls, it often is possible to close wounds with a lateral ligature, with a resulting stenosis instead of occlusion.

Transfusion

Transfusion may be used to strengthen the patient before operation for internal hemorrhage (bleeding duodenal ulcer, ruptured ectopic pregnancy). Unlike intravenous saline infusion, it may be started before the bleeding point has been seized, and it may keep the patient alive until that act has been accomplished. It is also most useful in combating the secondary collapse coming on several hours after operation. In cases where this is suspected, do not wait for the occurrence of symptoms before starting the transfusion. It is the best remedy we have.

(For further details see Treatment of Shock, also Vol. 1, Chap. VIII.)

Stimulation Other Than Transfusion

This is outlined under Traumatic Shock: **Under no circumstances is any stimulation to be administered until the bleeding has been controlled; before that time, while such measures may improve the quality of the pulse for a short while, they only increase the bleeding and hasten the patient's death.**

ROUTINE TREATMENT OF UNCONSCIOUS OR PARALYZED PATIENTS

In unconscious or paralyzed patients prevention of bed-sores and of overdistention of the bladder are the 2 points of the greatest immediate importance, leaving aside the question of stimulation.

In these cases one has to do the patient's thinking for him. He must be kept warm. If the bed clothes are slipping off, they must be replaced. The hot-water bottles or bags must not be allowed to burn him. The bed clothes should not be drawn so tightly that they cause pressure upon the toes; a wire arch is the safest way of preventing this.

Prevention of Bed-sores.—The prevention of bed-sores is summed up in 2 phrases: Avoidance of prolonged pressure, and scrupulous cleanliness. The locations where decubitus is most apt to form are over the shoulder-blades, sacrum, coccyx, trochanters, heels, and, rarely, the occiput. A water- or air-bed is the best device for preventing pressure upon the skin over these points; the bed is filled just enough to support the patient upon a soft cushion. If a water-bed is not available, the patient's position must be changed every hour or so. Thickly padded rings keep the skin over the bony prominences from being pressed upon. Only too frequently does one find that the size and thickness of the rings have not been varied to suit the individual's conformations, and with the rings in place, the skin over the heel or sacrum is still in firm contact with the bed.

Bed-sores develop much sooner if the skin which is being subjected to pressure is macerated with urine and feces. Consequently, after every movement of the bowels or passage of urine, the soiled skin should be gently washed, dried, rubbed with a little alcohol, dried again, and then powdered with sterile talcum. At least once a day the entire skin should be treated in this fashion. If the skin becomes very dry, it should be rubbed with vaselin, cocoa butter or lanolin.

The Treatment of Bed-sores.—Should a local decubitus actually form, it must be carefully watched for the first signs of pus formation. The dead skin should be trimmed away at its center even before demarcation has occurred, in order to allow free escape of secretions. If the decubitus is small, and the surrounding skin is not acutely inflamed (suggesting accumulation of pus beneath the skin), it may simply dry up and separate in due course of time. This is exceptional. As a rule, the entire thickness of the skin is involved in the necrosis; pus forms beneath the slough, which eventually separates from the living tissues, leaving a crater, at the bottom of which the deeper structures often lie exposed (fascia, bone). Besides keeping the affected area free from pressure, the treatment is that of any ulcerating wound, namely, stimulation of granulations, cleanliness, etc. Superficial sequestration often follows exposure of bone.

Care of the Bladder.—RETENTION.—With proper regard for strict asepsis, it is possible to catheterize at regular intervals for months and even years without having the patient acquire cystitis. This is a common experience in private practice; unfortunately it is rare in hospital wards. The proper method for catheterization is described in the section on the Urinary Tract (page 27).

Where one cannot do each catheterization oneself, and where the asepsis of those who would then be called upon to perform it is questionable, it may be safer to establish a suprapubic fistula from the very beginning, or, simpler still, to puncture the bladder with a trocar through which a permanent Pezzer catheter (Fig. 3) is inserted, the trocar being then withdrawn (Edwin Beer).

INCONTINENCE OF URINE.—If the overdistended bladder has leaked, i. e., if there is dribbling, simply tie a urinal in place. It is unnecessary to attempt further emptying of the bladder by pressing upon either side of the abdominal tumor it forms.

INVOLUNTARY URINATION.—Involuntary urination in the male is not particularly troublesome, because a urinal can be tied into place. In females it is almost impossible to keep the adjacent skin clean and dry unless a permanent catheter is used.

CYSTITIS.—The treatment of cystitis is described in detail in the section on the urinary tract.

Care of the Bowels.—RETENTION OF STOOL.—In case a daily enema has no effect, it may be worth while to try a dose of pituitrin, after first making sure, by digital examination, that no fecal impaction exists. (See Care of Alimentary Tract.)

INVOLUNTARY DEFECATION.—Involuntary defecations can often be controlled, for the time being, by clearing out the large intestine with an enema.

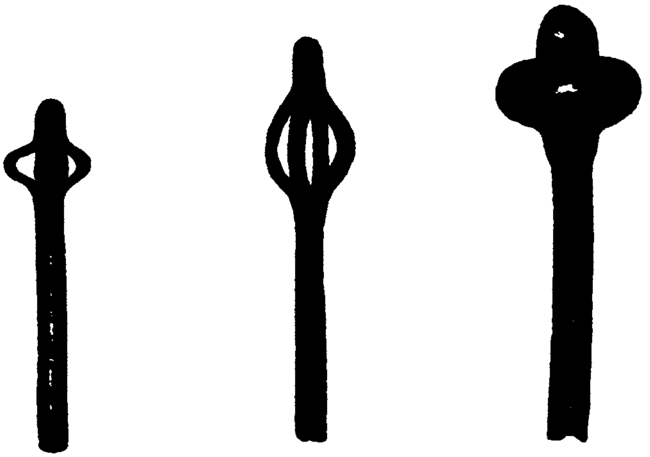

FIG. 3.—TYPES OF PEZZER CATHETER. (After Kelley.)

Make sure that the presence of old masses of feces filling the large intestine is not causing the diarrhea ("paradox diarrhea"). Probably more energetic measures than a simple enema will have to be used to correct this condition.

Care of the Paralyzed Limbs.—The paralyzed limbs are given daily massage. The slightest tendency toward formation of contractures is counteracted by suitable splints or other orthopedic measures. There is much to be said about the electrical treatment of paralyzed or weakened muscles, but space does not permit going into the details.

FOWLER'S POSITION

If the patient is given a back rest or if the bed is actually elevated high enough, there is always a tendency to slide down. To correct this, various supports for the thighs have been devised. For institutions, the permanent investment in a number of Gatch beds (Fig. 4) or, what is cheaper and equally effective, Mixter supports (Figs. 5 and 6), is to be recommended. On the other hand, in private practice, especially in the country, one must impro-

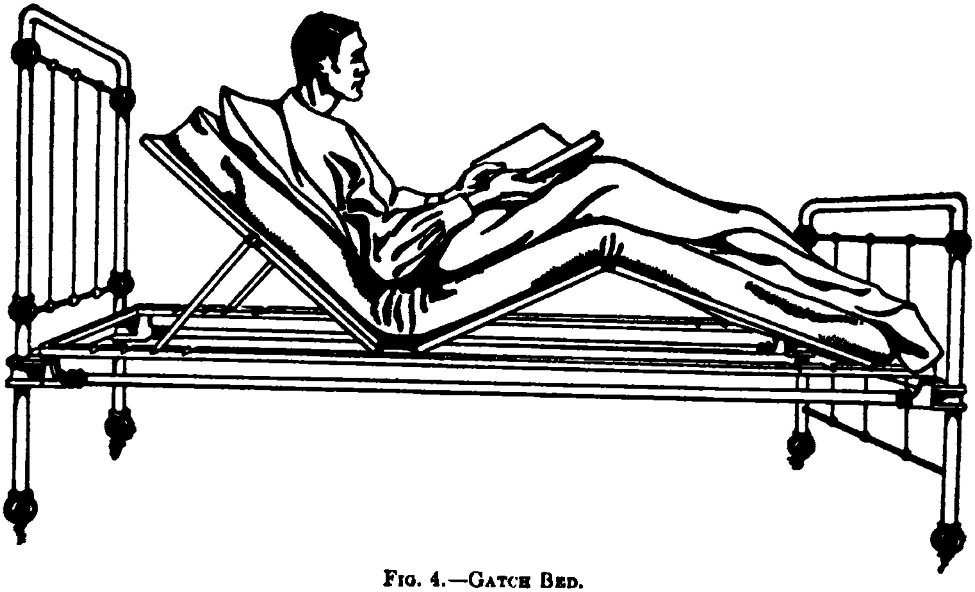

Fig. 4.—Gatch Bed.

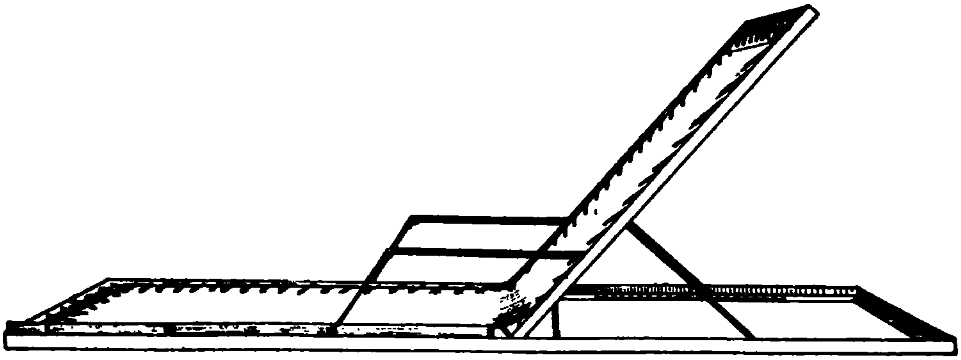

Fig. 5.—Mixter Frame.

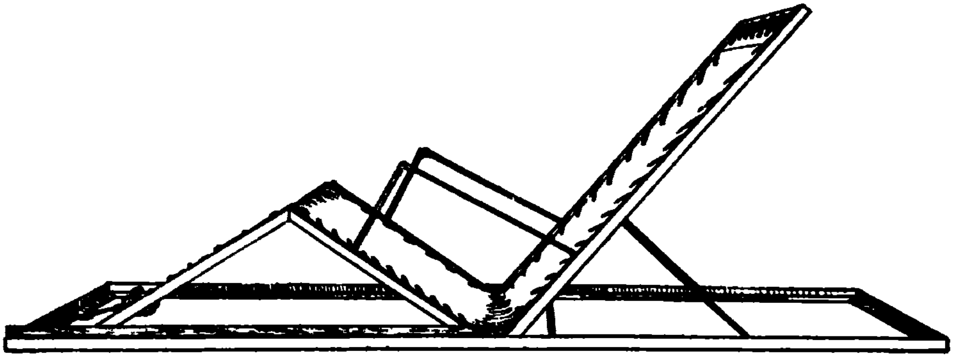

Fig. 6.—Mixter Frame.

vise with the materials at hand. Whether the bed is elevated 36 in. at the head or is kept level, a turned over chair being used as a back rest, in either case, the thighs need support.[1] The accompanying figure (Fig. 7) shows how this can be done by means of a length of clothes line and a folded pillow.

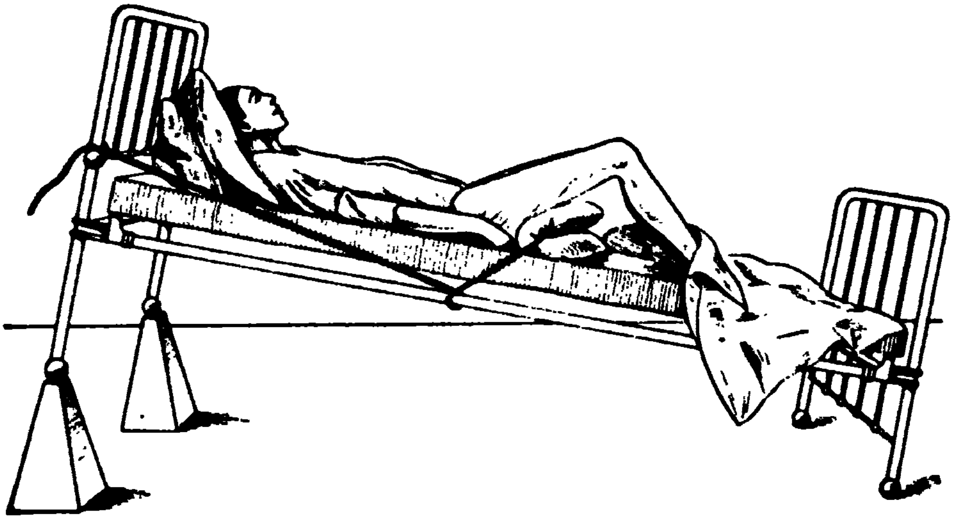

Fig. 7 Pillow and Rope Arrangement to Prevent Patient's Slipping Down when Head of Bed is Elevated

See to it that there is not too much pressure on the posterior aspect of the thighs; most of the weight should be borne by the buttocks as in sitting.

A stirrup suspended over the bed is of great convenience. By grasping it the patient is able to raise his body and to turn with minimum effort.

CARE OF THE URINARY TRACT

The Postoperative Urine. Transient albuminuria with a few granular and hyaline casts is the rule. Pus cells or mucus are of no significance in the urine of a female patient unless present in a catheterized specimen. Sugar in the urine of lactating women is nothing abnormal.

Retention of Urine.- Needless to say, every non-instrumental means at our command should be tried before catheterizing a patient. Among these are: (1) *warmth to the abdomen*, (2) *emptying the rectum by an enema*, and (3) *change of posture*. Many otherwise perfectly healthy women are unable to void when lying flat upon the back. Roll the patients over on one side or on the abdomen and let them stay there for an hour or so, or allow them to sit up, if possible. Certain operators ascribe the frequency of postoperative retention of urine after operations for hemorrhoids to the pressure of the anal cannula against the prostate; consequently they discard the cannula. Other surgeons have such a hemorrhoid patient get up and walk slowly around the bed, supporting himself by the bed frame. (4) The *psychic effect* is to be reckoned with. If some patients are left alone and unobserved they will void, whereas if one stands by and encourages them, they will not. The sound of running water is often helpful. Franko has suggested that the (5) *injection of 15 to 20 c. c. of glycerin* in the urethra and bladder will frequently cause the patient to void. This, however, is quite painful and disagreeable.

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[1] Raising the foot of the bed, when a back rest is used, helps a little in keeping the patient from sliding down.

Catheterization in the Male.—Wipe off the glans and thoroughly irrigate the anterior urethra with some antiseptic solution. Use plenty of lubricant; pass the sterile catheter with a sterile pair of forceps, not with the fingers. If difficulties arise and the hand must be used, use rubber gloves rather than the bare hand. If sterile rubber gloves are not available, a clean pair of rubber gloves can be practically sterilized by drawing them over the hands first and then scrubbing in soap and very hot water for a few minutes, and immersing in 1 : 500 bichlorid for a minute or 2.

Employ the utmost gentleness in passing a catheter to avoid making false passages. In certain prostatics, even a woven catheter is of no avail and a curved metal catheter must be employed to obtain an entrance into the bladder. Make a suprapubic puncture rather than inflict additional trauma in vain attempts to enter a strictured or inflamed urethra. (For the treatment of cystitis, see chapter elsewhere in this work; see also Care of the Bladder in the Treatment of Unconscious or Paralyzed Patients in this chapter.

Catheterization in the Female.—The labia minora are held apart (and kept so during the whole procedure; should they fall together, the preliminary cleansing must be repeated), the meatus is cleansed, the urethra is irrigated, and then a well lubricated catheter is inserted in the bladder. The tip of the catheter should touch nothing until it engages in the mouth of the urethra. That portion of the catheter which is to come in contact with the urethra should not be touched by the instrument or the hand which is passing it.

If retention occurs again, all the indirect means should be tried once more before resorting to catheterization. Postoperative cystitis is usually amenable to frequent bladder irrigations with mild antiseptics such as oxycyanid of mercury, 1 : 5,000, or permanganate of potash, 1 : 5,000, to be supplanted later on by solutions of silver nitrate.[1]

The management of a *permanent catheter* will be discussed in the special section dealing with postoperative treatment of the urinary tract.

Suppression of urine is treated by the usual medical means. If these are of no avail in acute parenchymatous nephritis, the kidneys are decapsulated or even split wide open (a procedure of doubtful utility in my opinion.—EDITOR). (See Treatment of Uremia, page 123.)

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[1] Silver nitrate solution must be made up with distilled water and must be kept in brown bottles, preferably in a dark place, to delay the disintegration of the silver salts as long as possible. If sterile water is used instead of distilled water the solution has an opalescent or milky hue depending upon the degree of its concentration. This color is due to precipitation of the silver salts by the solids in suspension.

ADMINISTRATION OF WATER

Thirst is one of the chief complaints of the patient who has just been operated upon, and it cannot be relieved by allowing him to drink, as this merely fills the stomach and increases the nausea. Inasmuch as the system is incapable of absorbing water taken in the usual way, in spite of its pressing need for fluids, various other methods are employed for effecting absorption of water.

Enteroclysis.—The use of normal saline solution has fallen off since it was found that plain water is as well tolerated, as quickly absorbed, and relieves thirst more effectually than saline solution. A patient just after operation needs water, not salt. The water may be administered (a) as an *enema* (to be given slowly) or (b) by the *Murphy drip method.*

Innumerable modifications of Murphy's original method exist. The essential principles, however, remain unchanged. In spite of its widespread adoption, one still sees improper technic frequently leading to unsatisfactory results. Hence the following remarks seem in order:

Although the bottom of the reservoir should never be more than 6 in. above the level of the anal orifice (that means that the pressure in the large intestine must not exceed that of a column of water 12 in. high), yet in many hospitals one sees the container 2 or 3 ft. above the patient's bed. This is far too high. Many people hold to the mistaken notion that if the water flows drop by drop, the height of the reservoir is immaterial—in other words, that the rate of flow will determine the ultimate pressure. Water finds its own level; if 1 of 2 containers connected by a tube is filled with water, the water will flow through the tube until the pressure is equal in both. If the level of the containers is now changed, and the lower container is a closed chamber, water will flow in and compress the air in this chamber until the pressure is equal to that of the height of the column of water which has been established. This equalizing of pressure will take a few moments if the tube connecting the 2 vessels is large, while if it is small, the process naturally is longer. Apply this principle to proctoclysis. If water from a reservoir placed 2 or 3 ft. above the patient, runs through a fair sized tube, the colon is overdistended in a few moments; if through a capillary tube, drop by drop, the overdistention is more gradual but none the less sure.[1] Gradual overdistention is much less apt to evoke peristalsis; hence many patients retain their infusion in spite of its improper administration. Many others, however, expel the water.

A very simple method of enteroclysis is to heat plain tap water to 100°, place it in a previously warmed thermos bottle[2] which has 2 holes in the cork through one of which is an air tube reaching to the bottom, and through the other a short outlet tube;

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[1] Mention of the rate of absorption by the intestinal mucosa is, for the sake of simplifying the argument, purposely omitted.

[2] If an ordinary douche bag or enema can is used, insolation is much less perfect than with the thermos bottle. The fluid can safely be kept at 116° F.; by the time it reaches the rectum so much heat has been lost that no harm can come.

invert the bottle at a level of about 1½ ft. above the bed, and then connect the outlet tube with a fine rubber catheter inserted 3 to 4 in. in the rectum. A pinch cock regulates the flow to a drop per second.

Whenever possible, after the catheter is once inserted, do not withdraw it as long as the proctoclysis is required. At the proper time (usually at the end of 2 hours) stop the flow by applying a second clamp to the tube without disturbing the original, carefully adjusted clamp which controls the rate of flow. After a pause of 2 hours, the reservoir is refilled and the clamp is removed, reestablishing the properly regulated flow without disturbing the patient. Of course, this principle does not hold when some other procedure, such as giving an enema, is to be carried out.

The Murphy drip is excellent for thirst, nausea and distress following general narcosis. If the infusion is started as soon as the patients are brought to bed, by the time they awake from the first postoperative sleep, they are infinitely more comfortable than exactly similar cases which have received no fluid in this manner.

Moderate distention occasionally follows prolonged use of the Murphy drip. Formerly, when rectal tips of fairly large size were being used, the gas and fluid from the large intestine were allowed to escape by simply releasing the cock on a Y connection interposed on the supply tube; with the fine catheters used at the present time, this is not feasible, and an enema must be given instead.

Subcutaneous Infusion: Hypodermoclysis.—When the patient needs water and the establishment of proctoclysis is contra-indicated—for example, after suture of the large intestine—hypodermoclysis is the next available method. At best it causes the patients a good deal of pain.

Although normal saline solution is customarily used, it might be worth while to ascertain whether plain, sterile, freshly distilled water does not possess the same advantages subcutaneously that it does when given per rectum.[1]

Sites for subcutaneous administration are the axillæ, inner aspect of the thighs, and beneath the breasts. Not more than 15 oz. can be given in any location. Massage helps to spread the fluid under the skin; needless to say it increases the existing pain a good deal. On account of the soreness left after the solution is absorbed, it is better to use one spot after the other for injections, to avoid giving the subject more pain than is absolutely necessary. Schoute (9) suggests injection of the prevesical space of Retzius; this is said to be painless and seems worthy of trial. People who have recently become thin, and whose skins are consequently lax, suffer less than others. Sharp needles hurt less than dull ones.

The reservoir may be raised as high as 4 or 5 ft. above the patient to facilitate the flow. The fluid in the container is kept at 110° F. Upon withdrawal of the needle, the puncture is covered with a small, thick compress of gauze, the size of a postage stamp, held in place by 2 very narrow strips of adhesive. If broad pieces of adhesive are applied and presently removed, the skin quickly becomes raw and sore, while if narrow strips are used, and are loosened with benzin, the skin remains in good condition and the same spot may be used a number of times. Upon the limbs a bandage should be used instead of adhesive.

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[1] I have been informed (personal communication) that in several German clinics plain water has been used for proctoclysis as well as for subcutaneous injection (not intravenous) for the past year or two, although nothing regarding it has been published. Grape sugar (see Treatment of Uremia) was employed in the subcutaneous injections with excellent result. The absence of salt in the subcutaneous infusion did not increase the pain.

Some authorities recommend a continuous hypodermoclysis similar to the enteroclysis—1 drop per second. The advantage claimed is certain absorption.

Intravenous infusion is to be used only in case of shock or hemorrhage. It is the most rapid method of furnishing fluid to the body. Its use in uremia is described later.

If too much water is absorbed by any of the foregoing methods, a general hydremia will take place—there is subcutaneous edema in various parts of the body. Withholding water for a few hours is all that is necessary under such conditions.

SIGNIFICANCE OF CHANGES IN VITAL FUNCTIONS

Pulse. The quality and the regularity of the pulse are of far greater importance than the rate. The pulse always becomes weaker as soon as the anesthetic is stopped, but as long as the patient's color remains good, the apparent weakness of the pulse should not cause alarm. The behavior and significance of the pulse in shock and in hemorrhage are treated in discussing those conditions.

HEART FAILURE (DECOMPENSATION) WITH RESPIRATORY SYMPTOMS.—Here the rapidity and irregularity of the pulse attract less attention than the striking dyspnea, cyanosis, and râles heard throughout both lungs.

With pulmonary symptoms occurring in the first 24 hours heart failure is to be suspected rather than pneumonia. The latter rarely develops before the second day.

In the following instance the head-down posture seemed to be of great benefit. The patient, a young prize fighter of 19, did not react well after operation for hemorrhoids (ether anesthesia). His pulse remained weak and rapid, and, about 8 hours after operation, he developed acute general pulmonary edema with much cyanosis. The foot of the bed had been raised about 18 in. because of his apparently shocked condition, and it was noticed that large quantities of clear, thin mucus and serum drained away through the nose and mouth. Under the administration of generous doses of morphin and atropin the râles subsided, the discharge of serum and mucus by mouth ceased, the heart's action improved, and by next morning the patient seemed as well as ever. This observation was made by Dr. Charles Koenigsberger of the Mt. Sinai Hospital Interne Staff.

In the aged or in those with high tension, such a lowering of the head is fraught with danger of cerebral hemorrhage; here phlebotomy may be of the greatest service.

Phlebotomy is indicated in cardiac decompensations at any time of life which do not prove amenable to the customary measures.

HEART FAILURE WITH ABDOMINAL SYMPTOMS.—Sudden failure of the right heart may sometimes cause such rapid and extreme swelling of the liver that the symptoms in the hepatic region overshadow all others. There is exquisite pain in the right hypochondrium; rigidity is so marked that palpation of the enlarged liver is impossible; the dulness, which may extend to the umbilicus, has been interpreted as caused by an exudate due to acute inflammation. The rapidity, irregularity and poor quality of the pulse have been ascribed to shock from acute perforation of the gall-bladder or stomach, and laparotomy was actually and mistakenly done.

If one bears in mind the facts just cited and considers, among other things, the possibility of heart failure, the patient may derive much benefit.

Respiration.—Respiration may be slowed somewhat by the exhibition of morphin. The respiratory movements should be as free and unhampered as possible. Often they are restricted not only by chest bandages or restraining sheets which are too tight, but also by abdominal binders, especially those put on in the operating room while the patient is unconscious. It is remarkable how promptly restlessness and discomfort are relieved by simply loosening a tight bandage or binder.

HYPOSTATIC CONGESTION.—The patient should be required to take a number of deep inspirations every few hours and should change his position from time to time. The prevention of hypostatic congestion largely depends upon free, ample, respiratory motions and frequent changes in position, as well as upon a good cardiac action. Abdominal distention must not be forgotten as one of the most important causes of hypostatic congestion. When the latter condition is well established, it usually goes on to a speedy, fatal termination in spite of routine treatment, such as cupping and the administration of atropin and various modes of stimulation.

POSTOPERATIVE PNEUMONIA.—TREATMENT.—Once the condition is established, the treatment consists in supporting the patient's strength, preventing interference with respiration by abdominal distention, and the use of a reliable digitalis preparation upon the slightest suspicion of cardiac weakness—in short, the well recognized principles of medical treatment.

PREVENTION.—Ether narcosis should be avoided in subjects with bronchitis, emphysema, cardiac decompensation, chronic alcoholism, and in the aged. To circumvent these obstacles a number of ways lie open.

Individuals suffering with coryza or bronchitis should wait until these conditions have subsided before they are given a general anesthetic. If the operation is imperative, (1) a preliminary injection of scopolamin and morphin, given an hour or 2 before operation, brings the patient to the operating table in a drowsy indifferent state, and the actual loss of consciousness is brought about by laughing gas—oxygen narcosis (this is Crile's favorite method): (2) intravenous anesthesia may be employed (at Kümmell's clinic in the Eppendorfer

Krankenhaus in Hamburg a 5 per cent. ether—normal saline solution is used; in alcoholics "isopral" in normal saline is used to obtain loss of consciousness, after which narcosis is continued with the ether solution); lastly (3) local anesthesia may be used in any one of its forms (local infiltration, blocking of the nerves at some distance from the wound or even at their exit from the spinal canal—paravertebral anesthesia—or spinal anesthesia).

In certain quarters, notably on the continent of Europe, it has been maintained that postoperative pneumonia occurs just as often after local anesthesia as after general. At the clinics from which these reports emanate, this is doubtless the case, but that certain contributory factors are present, must also be borne in mind. The patients are laid upon the operating table covered only by a sheet; little if any provision is made for keeping them warm while the operation is in progress, and as the same operation takes a little longer under local anesthesia than under general narcosis, it is not surprising that some individuals, under such circumstances, acquire either bronchitis or even pneumonia.

On the contrary, of recent years the tendency on the Continent has been to make as much use of local anesthesia as possible (there are practically no professional anesthetists abroad). At Wilms' clinic in Heidelberg over 60 per cent. of the operations are performed under local anesthesia.

General Narcosis.—A preliminary injection of morphin, gr. 1/6, and atropin, gr. 1/120, lessens secretion of mucus during narcosis. The *personal ability of the anesthetist* is also a factor of prime importance in prevention of postoperative pulmonary complications. It stands to reason that a person who is constantly giving anesthetics will give a smoother narcosis than one who never has had sufficient experience or who only administers an anesthetic occasionally.

The patient *must be kept warm* before, during, and after operation.

When the stomach is filled with septic material—for example, in intestinal obstruction with fecal vomiting or pyloric obstruction with stagnation—gastric lavage must invariably precede induction of narcosis. If this is omitted, vomiting is sure to occur and the risk of aspiration pneumonia from even the smallest amounts of such material is very great.

Oral Sepsis.—The presence of *carious teeth* also predisposes to lung infection. *Gangrene of the lungs*—not pneumonia—is especially apt to occur after general narcosis in people with carious teeth.

Intratracheal insufflation absolutely prevents the entrance of foreign material into the trachea or bronchi. It is the most useful factor we have in preventing the occurrence of aspiration pneumonia.

After operation, the following measures are of use: Assumption of a sitting posture; or, if lying down, frequent change (every hour) from one side to the other; the taking of frequent deep inspirations; lastly, the expulsion of mucus, the presence of which is shown by tracheal rattling. The pain evoked by coughing often makes the patient unwilling to attempt to get rid of the phlegm;

morphin or aspirin may lessen pain to such an extent that the patient may be induced to expectorate.

Temperature.—The usual postoperative rise in temperature was mentioned in describing the customary (postoperative) course of an uncomplicated case. The height of this rise largely depends on the time consumed and the amount of trauma inflicted at operation, and upon the capacity of the patient's tissue for reaction. Taken by themselves, variations in temperature mean nothing. Transitory high temperature is of no significance, provided the patient's general condition is good, and provided there are no local inflammatory symptoms.

Temperature may be due to slight infection of the wound, to aseptic absorption, to constipation, or to bronchitis. If the general condition of the patient remains good, be careful to avoid doing too much. Do not disturb the dressings of the wound unless there is very good reason to believe that infection is present. In the presence of a suppurating wound, the return or the continuation of fever generally indicates retention.

A normal or subnormal temperature in the presence of a recent spreading infection is of the gravest prognostic import. Such cases usually die. They have no powers of resistance; hence, they show no reaction.

ALIMENTARY TRACT

Care of the Mouth.—In hospitals where the nursing is competent there is no complaint about the condition of the patient's mouth and teeth, but in many otherwise first-class institutions there seems to be a good deal of indifference to taking proper precautions for oral cleanliness. In summer, flies may be seen upon the tooth brushes kept for each patient alongside of his bed. Often there is no provision for sterilizing the dishes and eating utensils of patients with tonsillitis or bronchitis, and the spread of these maladies to others in the same ward is thus favored.

In modern, well-managed institutions these faults do not obtain.

Postoperative Abdominal Distention.—Although this subject properly belongs under the section on the abdomen in the following chapter, laparotomies form so large a majority of operations at the present time that, for the reader's convenience, the matter is taken up at this point.

Distention usually does not begin until 12 to 24 hours after operation. If promptly recognized and properly treated, it subsides in a very short time. The long standing, unrecognized or neglected cases are the most intractable.

Normally the expulsion of flatus requires a little increase in abdominal pressure to overcome the resistance of the sphincter. If the patient has a fresh laparotomy wound, he naturally does not care to contract his abdominal walls and give himself pain, hence the necessary pressure is not exerted to expel the gases and they accumulate.

The more thoroughly a patient is purged, or the more drastically the lower bowel is emptied by means of enemata before operation, the surer is such a patient to suffer from marked postoperative distention.

TREATMENT. A fair sized *rectal tube* passed just through the sphincter and allowed to lie in this position keeps the lower end of the large intestine patent and allows the escape of gas. *Turpentine stupes* to the abdomen are excellent counterirritants for evoking active peristalsis. If stupes and the rectal tubes are of no avail, a *low enema* should be given.[1] If this is not effectual, a *high enema* with tincture of asafetida (asafetida is more effectual than essence of peppermint) should follow.[2]

If the distention persists and is most marked in the upper half of the abdomen, there should be no hesitation in passing a *stomach tube*. If the stomach is found filled, the stomach tube should be passed once every 3 hours until the stomach is empty. (See Dilatation of the Stomach, below.) If, on the other hand, the stomach is found empty, a rectal tube should once more be inserted and a *series of enemata* should be given with the rectal tube lying in place. Plain water may be used. The water should be allowed to flow in until the patient feels a slight discomfort. It is held a little while and then allowed to run out through the rectal tube into a pail, the end of the tube staying below the surface of the water in the pail so as to apprise one of the expulsion of gas if it should occur. Several gallons may be used before an effect is obtained. Only in cases of actual mechanical intestinal obstruction have I seen these serial enemata fail.

For the reader's convenience, the following formulæ are given:

Soapsuds enema 1 to 2 pts. up to 2 qts. of tepid water with white soap if possible. Remove foam from top.

Olive oil enema:
Olive oil 4 oz.
Soapsuds 2 oz.
Make an emulsion and give warm to be retained.
Follow in ½ hour to 1 hour by regular soapsuds enema.

Ox gall enema:
Ox gall 1 oz.
Olive oil 4 oz.
Given as oil enema; follow with soapsuds or mix and give all together.

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[1] O. Kleinschmidt (3) recommends 2 or 3 tablespoonfuls of glycerin in a pint of water as an excellent means of starting peristalsis. It is said to cause less discomfort than the customary enema.

[2] It is impossible to pass a rectal tube higher than 6 in. from the anus. If more of the tube is passed in, it simply curls itself around in the rectal pouch, increasing the discomfort of the patient but passing no higher in the intestine.

Turpentine enema:
Olive oil 4 oz.
Spts. turpentine 1 dram.
Make an emulsion. Follow with soapsuds enema.

Asafetida enema:
Asafetida 2 to 4 drams.
Ox gall 1 dram.
Turpentine 2 drams.
Soapsuds 1 to 2 pints.

Discrimination must be used in carrying out the treatment just outlined to avoid undue exhaustion of the patient. If one method fails, allow a short rest before trying another.

In some instances the Murphy drip infusion is apt to cause postoperative distention. If an enema be given and the Murphy drip stopped for a few hours, this usually suffices.

None of the so-called peristalsis-producing *drugs* has proven of definite value. Prominent among these are atropin, physostigmin, and hormonal. Pituitrin has recently been used for this purpose. However, the number of cases in which it has been employed is not sufficiently large to enable one to draw any definite conclusions.

No cathartic should be administered until one is sure that obstruction does not exist.

Operation is to be resorted to only after all the above-mentioned means have been proved of no avail. (See Vol. II, Chap. II, Postoperative Operations, for details about the relief of adhesions,[1] for indications for and technic of enterostomy, etc.)

Postoperative Care of the Stomach.—Nothing is to be swallowed until all nausea has disappeared (as said elsewhere, thirst is best relieved by enteroclysis of plain water). If vomiting persists more than a few hours after consciousness has been regained, and if the vomiting is inadequate and protracted, allow the patient to swallow a glass of water. This is almost sure to be followed by a copious emesis by which, it is hoped, the stomach will be completely emptied, thus obviating the use of a stomach tube. If, however, this is ineffectual, do not hesitate to wash out the stomach. There should be no more hesitation about emptying the stomach with a stomach tube than there is about ordering an enema. **A stomach which is found full is to be emptied every 3 hours until it is found empty.** The patient should also assume the **posture** most favorable for passage of gastric contents into the intestine, namely, lying upon the right side.[1]

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[1] In spite of numerous emphatic claims, so far nothing has been found which prevents formation of adhesions. The recently published article of Saxton Pope (8) contains experimental proof in favor of pouring a 3 per cent. citrate of soda in 2 per cent. sodium chlorid solution into the abdominal cavity whenever formation of postoperative adhesions seems likely. No harm had followed its application to hospital cases. The time is too short to tell whether this actually prevents adhesion formation.

ACUTE DILATATION OF THE STOMACH. Although most frequently seen after laparotomy under general narcosis, this condition has also occurred in perfectly healthy people who have gorged themselves with an unusually large meal. Moreover, operations under general anesthesia upon other parts of the body than the abdomen have been followed by acute dilatation of the stomach. For these reasons the subject is mentioned now instead of in the following chapter.

Von Haberer (2) differentiates between acute dilatation of the stomach and what he terms acute arteriomesenterial ileus. According to him, *acute dilatation of the stomach* consists in a simple atony of that structure. The patients are thirsty and very restless; their increased respirations and rapid pulse are not accompanied by any rise in temperature. The onset is so gradual that it is practically imperceptible. Often **there may be no vomiting**; if there is, it consists in regurgitation of small amounts of fluid without apparent nausea; there is no peristaltic activity as shown by violent emesis (see below). As soon as the stomach is emptied, the pulse and respirations drop to normal, there is no more restlessness, and the patient usually drops off to sleep.

Arteriomesenterial ileus gives an entirely different clinical picture practically that of a high intestinal obstruction. The onset is sudden and is marked by pronounced collapse and violent repeated vomiting, which persists in spite of stomach washings. The pulse is small and rapid, as in peritonitis; the respirations are frequent and shallow and are not improved by the passing of the stomach tube. There is absolute obstipation. This violent peristaltic stage is frequently followed by a paralytic stage, i. e., acute dilatation of the stomach.

The mechanics of acute arteriomesenterial ileus are explained by von Haberer as follows: The band formed by the superior mesenteric artery lying across the transverse portion of the duodenum is pulled upon (not released) by that portion of the small intestine lying in the true pelvis. (It is conceivable that pressure from a full bladder in front may be just sufficient to prevent the intestines from moving up out of the pelvis.) The pull upon the mesentery obliterates the angle formed by the superior mesenteric artery with the vertebral column, and the duodenum which lies between these 2 structures is compressed obstructed at that point. One of 2 things now happens. Either the stomach (and that portion of the duodenum above the obstruction) empties itself by repeated violent vomitings (this may later on go over into a dilatation); or the angle of the esophagus with the stomach at the cardia may form a valve preventing the stomach from emptying and quickly leading to an enormous dilatation. (Any extreme dilatation of the stomach causes it to impinge against the abdominal wall in front and the vertebral column behind, incidentally compressing that part of the duodenum lying in front of the vertebral column, thus further aiding in maintenance of the dilatation.) At autopsy in the cases where death occurred from exhaustion during the period of violent emesis, while the stomach itself showed no dilatation, the pylorus was widely patent and the duodenum down to the crossing of the superior mesenteric artery was widely dilated. Von Haberer interprets this as evidence that the gut had made a vain effort to overcome the obstruction below and that the stomach had constantly emptied itself through the esophagus. This explains those cases in which dilatation of the stomach or high intestinal obstruction was diagnosed and in which no obstruction could be found either at operation or at autopsy.

[1] Markovic and Perussia (5) have shown that a healthy stomach empties itself in 2 hours if the individual lies upon his right side, 4 hours if on his back, and 6 hours if on his left side.

Treatment.—Simple atonic dilatation usually responds to lavage and abstention from food. The right-sided posture, as said before, aids in draining the stomach into the gut.

Acute arteriomesenterial ileus is uninfluenced by gastric lavage. The rapid, high-tension pulse does not improve after emptying the stomach; in short, the obstruction is not relieved, and its symptoms naturally continue. Postural treatment, unless the small intestines are firmly adherent in the pelvis, relieves the condition as suddenly as it commenced. Lying upon the right side or assuming the knee-elbow position favors release of the intestines. Where postural treatment was of no avail in von Haberer's cases, laparotomy revealed adhesions of the small intestine in the pelvis (following previous gynecological operations).

Operation is the last resort in the treatment of this condition. The mortality has been very high because of the exhausted condition of the patients.

Westermann (12) recently has recommended *permanent gastric siphonage in acute dilatation of the stomach* as being less trying to the patient than frequently repeated lavage. A tube 2 meters long is introduced through the nose for a distance of 50 cm., being fixed in place by a heavy silk thread. The tube has a diameter of ½ cm. and should not be too thin-walled. The free end of this tube is provided with a funnel, and empties itself into a vessel placed on the floor beside the bed. The intestinal gases often interrupt the outflow. During the first day, a test as to whether or not the siphon is properly working is made every half hour; if not, siphonage is re-established by filling the elevated funnel and depressing it anew. With proper care, vomiting will not recur. Further, the patient is made much more comfortable by being allowed to drink all he wishes. Very little fluid is absorbed, as most of it promptly escapes by way of the tube, hence administration of fluids by other means is indicated.

One drawback of the method has so far been discovered, a pressure sore of the esophagus was found at autopsy upon a patient in whom the tube had been in place for 48 hours; some transient soreness in swallowing after the removal of the tube has occurred in several other cases.

Etiology.—Von Haberer states that those who have lost much flesh and have acquired visceroptosis are especially prone to acute arteriomesenteric ileus. Operations by which the capacity of the abdomen is altered—for example, removal of large fibroids of ovarian cysts—predispose to arteriomesenteric ileus.

Any *general narcosis* may be followed by gastric dilatation. It has also followed operations under local anesthesia.

Errors in diet, especially at the time when change is made from fluid to solid nourishment, constitute an important etiological factor. (Every prolonged general anesthetic paralyzes the stomach and intestines for some days after operation. The greatest care must be exercised in avoiding overloading of the stomach because of this paralysis.)

Lastly, *mechanical compression of the duodenum* by tamponade of the gall-bladder or right kidney region has caused acute dilatation of the stomach, which was relieved by removal of the offending packings.

HICCOUGH.—Hiccough is one of the most troublesome of the minor postoperative complications. One should endeavor to ascertain the cause and remedy it if possible. Among other remedies may be mentioned pulling the tongue forward and holding it in this position, holding the breath, lavage of the stomach, and the administration of morphin or atropin.

Diet.—It is better that nothing shall be swallowed for 12 or even 24 hours after operations under general narcosis. When judgment indicates, one may begin to give small amounts of fluid as hot as can be borne to drink—say 1 oz. an hour for several hours, until it is certain that these small quantities are well borne. If such proves to be the case, the amount can be increased. By this time the urgent desire for fluid has gone, the vigilance of the attendants slackens, and errors in diet are very apt to occur.

With the average well nourished individual, there is no need for any haste in giving solid food. Be guided by the individual himself. Wait until he asks for something more substantial than fluids. Then begin with small meals at frequent intervals, never allowing the hunger to be completely satisfied. Nothing so permanently abolishes a convalescent's appetite as its complete satiation. It takes from 4 to 6 days for the alimentary tract to regain its normal tone; hence, during this time overloading the stomach must be avoided. It is not unusual for a patient who has done well the first few days to lose his appetite shortly after changing to solid food, and to have his improvement come to a standstill, for no other reason than a prematurely large meal. Ordinarily this is of slight moment; a little starvation with or without a stomach wash, followed by a restricted fluid diet, cures the average case. But in weak asthenic types, such a delay in convalescence may be just enough to turn the balance the wrong way.

Except in a few restaurants and really exceptional homes, the art of cooking in America is still in the camp fire or kettle-and-frypan stage. It takes a hungry man to attack the average restaurant or boarding-house meal. Hospitals are no exception to this general rule. The quality of the raw materials supplied to the kitchen is, as a rule, excellent. Right here is the crux of the matter. Either the cooks employed are not sufficiently competent, or, if of adequate caliber, they are not held up to the requisite standard by the management. One hears a great deal of talk about *dietetics* but perceives little change in the *taste* of the food.

There are various grades of defective preparation. The bread and meat are fair, although there is plenty of room for improvement. The vegetables are at the bottom of the scale. Yet in many instances they form the most important factor in the scientific management of digestive and metabolic derangements. Although not as up to date in certain other respects, in the preparation of everyday food certain hospitals of the nursing Catholic sisterhoods are far ahead of other institutions.

The presence of food ought to stimulate the appetite, not annihilate it. Tastes vary. What is tempting to one is distasteful to another. It is hard enough to ascertain what will tempt a convalescent native-born American with whom the surgeon has certain things in common. It is still harder to do the same for the foreign-born patient. In such a case the following hints may be of use: An Italian will be tempted by boiled macaroni with plenty of grated Parmesan cheese or a few slices of sausage containing a little garlic. The Hungarian loves a stew containing plenty of paprika. (Paprika should be cooked with the other ingredients, not added raw after the dish is finished, as is so frequently done.) A bit of salt herring is especially attractive to the Russian Jew. In short, if a little care is taken to ascertain the individual taste of each nationality, one quickly realizes the truth of the old adage about one man's meat being another's poison. In other words, certain people relish, enjoy, and assimilate better than anything else dishes which are actually indigestible for others. Such catering to the taste of foreign-born patients entails a little additional care, but practically no added expense because the material is so cheap. On the other hand, these patients are extremely grateful for such congenial changes in their diet.

RECTAL FEEDING will be treated in the special section under Operations on the Mouth and Larynx.

Cathartics.—As said in my introductory remarks, with a proper diet one should be able to dispense with the habitual use of cathartics and enemata. Another means of avoiding the giving of cathartics is a judicious utilization of tobacco, coffee, and alcohol. A man who is a habitual user of these regains his normal state much more rapidly if permitted his accustomed indulgence within the limits of moderation. On the other hand, depriving such a man of his customary solace often leads to obstinate constipation.[1] A hospital is not a reform school, it exists to get sick people well, not to abolish life-long habits. (This, of course, does not apply to dipsomaniacs or drug habitués.)

If, in spite of the means just mentioned, no result is obtained, a cathartic may have to be given. The proper choice requires discrimination. Space does not permit a detailed discussion of the various drugs and their action. At each institution there is some favorite powerful agent for stirring into activity the obstinately inert intestines of the average member of the working classes. Thus, at one place, equal parts of compound licorice powder and Epsom salts (dr. ii each) is the sovereign remedy; at another, compound cathartic pills (aptly termed "little devils") are the house surgeon's stand-by. Such drastic purgatives are often the only means for obtaining a normal evacuation.

With more intelligent persons methods change. Find out from the patient what cathartic suits him best, and be guided accordingly. This often saves the patient much unnecessary discomfort and the physician much experimenting.

[1] Vice versa the presence of constipation may spoil the patient's appetite.

POSTOPERATIVE BACKACHE

Many patients complain more of a pain across the small of the back than they do about the laparotomy wound. This is relieved to a certain extent by supporting the back with plenty of pillows. It can be prevented by supporting the back in a similar way upon the operating table.

POSTOPERATIVE HEADACHE

Headache belongs to the group of symptoms following the administration of a general anesthetic. The sooner the body absorbs water, the sooner the headache, nausea, and other symptoms are relieved. While the headache is present, quiet, darkness and ice-cloths to the forehead minimize the patient's discomfort as much as possible. Headaches which last longer than 18 hours usually are caused by some other condition than the administration of the anesthetic.

SLEEPLESSNESS

After the first day or 2, lack of sleep is a frequent complaint. Before resorting to a hypnotic, such as trional (gr. xv), try to accomplish your purpose by preventing sleep during the daytime, a glass of ale at the proper sleeping time, or some very solid reading matter; the last is especially effective if read aloud in a monotone by someone who does not understand it.

GENERAL HYGIENE

Sunlight, Fresh Air, etc. The beneficent effects of sunshine, fresh air, and cheerful surroundings cannot be overestimated. The country hospitals are better off in this respect. With plenty of ground at their disposal, they are not cut off from light and air by adjacent structures. Often there are sun parlors at the ends of the wards into which the beds of the patients on the shady sides of the wards can be wheeled without much effort. The brilliant results of Rollier in cases of surgical tuberculosis have called attention to this much neglected factor.

Exercise.—Systematic exercises in bed are of great value in keeping up the general tone. The following list of exercises is taken from an excellent article by E. H. Pool (7) which also contains the literature up to date:

Pool says: "While it is impossible to estimate accurately the effects of postoperative exercises, their trial in a number of cases seems to support the theory that as a result of their use, the general circulation is improved, the functions of the body are performed in a more normal manner, the patients feel better, muscular weakness and atrophy are diminished, and after getting up, exertion is less fatiguing and return to normal is more rapid. The two objections—possible interference with the repair of the wound and danger of embolism and thrombosis—may be disregarded. No injury to the wound is to be anticipated, provided proper exercises are selected and intelligent instruction is given to the patient; moreover, there is no valid reason to fear embolism and thrombosis; in fact, there is some reason to believe that the exercises may be advantageous as a prophylactic against these complications.

"If postoperative exercises are desirable, it is essential that their use should be systematized. A general policy may be adopted in each variety of operation as to the kind of exercises, the number of times each is to be performed, the number of times a group of exercises is to be carried out each day, and definite times for their performance. Yet in many cases the condition of the patient and the nature of the operation demand variation from a fixed routine, so that although a definite plan may be followed in general, discrimination is essential in every case.

"1. Ankles flexed and extended.
"2. Lower extremities rotated separately.
"3. Hip flexed and extended.
"4. Knee flexed and extended.

"Both 3 and 4 should be used with care after a celiotomy; frequently they should be restricted to one side, the other thigh being somewhat flexed; thus after appendectomy or right inguinal hernia, they should be omitted on the right side.

"5. Fingers flexed and extended.
"6. Wrists flexed and extended.
"7. Forearms pronated and supinated.
"8. Elbows flexed and extended.
"9. Arms flexed and extended.
"10. Neck flexed by raising head.
"11. Head moved from side to side (lateral flexion not rotation).
"12. Deep breathing.

"Those exercises appropriate to a given case having been selected, the patient is instructed in their performance.

"The instruction of the patient or attendant as to the exercises is simplified by the use of such a form as the following in conjunction with the illustrations.

"Instructions for exercises following *Right Inguinal Hernia* or *Interval Appendectomy*.

"Begin postoperative exercises on *third* day.

"Number of times daily: *three*.

"Times for exercises (*regular times should be prescribed*).

"Number of times each exercise (always stop short of fatigue): Begin at 10, increase gradually to about 30.

"Exercises: 1-12 with exceptions as follows: left side only, 3 and 4. (In a hernia the operator may consider it wiser to omit or postpone 3 and 4.)

"All movements of the limbs should be performed with voluntary muscular resistance."

POSTOPERATIVE THROMBOSIS AND EMBOLISM

Aseptic Thrombosis.—In a certain small percentage of cases, thrombosis of the saphenous and femoral vein occurs. It is usually first observed about the tenth day. Treatment consists in moderate elevation upon pillows, the application of ice-bags, and perhaps a little codein for pain during the first few days. In course of time (3 to 4 weeks) the condition subsides of its own accord.

The prevention cannot be exactly outlined, because the etiology is obscure. The condition arises as frequently after "clean" operations as after those for acute inflammatory conditions. Certain operators assert that getting the patients out of bed on the second or third day improves the circulation and tends to prevent the formation of thrombi. Other surgeons, of equal experience, deny this and maintain that the thrombi occur with equal frequency whether the patient gets up early or late. The left femoral vein is more frequently involved than the right, regardless of the location of operation.

Systematic exercises in bed do not subject the patient to as great a strain as walking 3 days after a major operation and yet offer a way of keeping up the general tone without incurring especial risk.

Suppurative Thrombosis. In the presence of suppurative thrombosis (an extremely rare condition), ligation of the vein proximal to the point of involvement and its extirpation or simply laying open of the suppurating foci is indicated where this is feasible, that is, where the thrombi have not already extended to the great veins of the trunk. Thus the internal jugular is ligated to prevent further spread of a sinus thrombosis. Again ligation of the pelvic veins has been practiced in puerperal sepsis. The ligation of the saphenous vein or the lateral incision of the vein and the removal of the thrombus are final examples.

Emboli. The removal of emboli from the large pulmonary vessels (Trendelenburg's operation) has been done abroad about 25 times. Several of the patients have lived for days afterward and have eventually died from pneumonia or sepsis, but not from a second embolism. Removal of emboli from the bifurcation of the aorta, the femoral, and popliteal arteries has been done with complete success. In each case the vessel wall was closed again by Carrel suture.

POSTOPERATIVE PAROTITIS

This is usually the result of trauma inflicted by some horny-handed young anesthetist. Some people are more susceptible than others. Application of a Priessnitz pack often affords much relief. It is rarely necessary to open and drain.

POSTOPERATIVE PARALYSES

To enumerate the causes of the various postoperative paralyses is to point out their prevention. As a rule, the motor paralysis is more marked than the sensory.

Constriction Paralyses.—FROM TOURNIQUETS.—Tourniquets, too tightly applied, have caused paralysis. A nurse is apt to apply a tourniquet too loosely, an orderly too tightly. If present, the surgeon should assume responsibility by applying the constrictor himself if there is the slightest doubt regarding the ability or discretion of his subordinates. The pneumatic tourniquet has the advantage of more accurately controlling pressure than any of the other methods.

CASTS.—If a cast is split longitudinally immediately after application, the danger of undue constriction is minimized. A strip of heavy muslin bandage laid lengthwise along the limb just before applying the plaster, serves as a guide in splitting the cast later.

VOLKMANN'S ISCHEMIC PARALYSIS.—Volkmann's ischemic paralysis is caused by the undue constriction of tourniquets, casts, and bandages. If the constriction is relieved within a few hours, and such measures as elevation and massage are promptly instituted to restore the circulation, the chances for recovery are good. Later on the damage may be irreparable, depending upon the amount of muscle which is changed in the process. According to Alfred S. Taylor, there may be 3 distinct types of Volkmann's paralysis (see also Vol. I, Chap. XIII):

(1) More or less fibrosis without damage to the nerves.

(2) Paralysis as well as fibrosis.

(3) Fibrosis with gradually developing paralysis due to a slow constriction of the nerve fibers by the fibrous tissue surrounding them.

As the atrophy develops, typical contractures appear. Only exceptionally, in even the less severe cases, after months of massage and electrical treatment, is there recovery of the disabled muscles. In certain unfortunate instances, the brawny induration, instead of being followed by atrophy, has ended in gangrene of the constricted limb.

There seems to be an individual susceptibility to the acquisition of a Volkmann's paralysis; some individuals develop the condition after comparatively slight trauma, others escape in spite of a much greater degree of local injury.

There is a growing tendency to discard the use of the tourniquet in operations upon the limbs; as said elsewhere, in performing amputations some surgeons (notably Lambotte) use no constrictors; they first expose and ligate the large vessels before dividing the tissues transversely. In resections constriction has also been found unnecessary.

Anesthesia Paralyses (So-called).—Hyperextension of the arms above the head has been followed by brachial plexus palsy. The mechanics of this lesion are still a matter of dispute; but it makes no difference whether the humeral head or the clavicle does the damage, the position is bad and must not be used.

The arms must not be permitted to hang over the sides of the operating table, as there is likelihood of compressing the musculospiral nerve between the shaft of the humerus and the edge of the table.

Trendelenburg's position has its special paralyses. The brachial plexus has been injured by an excessive pull exerted upon it by too much pressure upon the shoulders by the shoulder pieces. Too great a pull upon the legs flexed on the thighs has resulted in local paralysis. Each of these conditions was caused by failure to distribute the weight to be supported among several points; instead of this, it was allowed to concentrate upon one region.

It is the duty of the anesthetist to make sure that none of these accidental nerve palsies shall occur. This is especially so after the operation has started —the surgeon has his own work to do and should not be diverted from it.

With the patient lying upon the side, the nerves of the under arm are subject to dangerous pressure unless special provision is made to guard against this.

After all of these pressure paralyses, the nerves, as a rule, regenerate in due course of time; occasionally they do not. The care of postoperative paraplegia is outlined on pages 23, 24, 25, 120 and 121.

Paralyses from Division of Peripheral Nerves at Operation.—The divided nerve must be sutured as a matter of course. Neglect of this at the primary operation necessitates a secondary search for and union of the ends. This may be extremely difficult on account of scar tissue. Although others hold the opposite opinion, A. S. Taylor in over 100 instances has never seen atrophy of the nerve trunk distal to the point of division, even after several years had passed since the division took place.

TREATMENT OF THE WOUND

CLEAN WOUNDS

Removal of Stitches, Pincettes, and Adherent Gauze.—In clean wounds, the first dressing is changed when it is time to remove the stitches. This varies with the nature and locality of the wound. Thus, in wounds of the face, the stitches may be removed as early as the second day, provided there is no tension on the suture line. On the other hand, where the cosmetic effect is not so important, the stitches are usually taken out on the fifth, sixth, or seventh day. If there is a tendency to separation, the alternate stitches are removed on 1 day, adhesive plaster straps (sterile) taking their place, and the remaining stitches are taken out a day or 2 later. Michel clips (pincettes) are taken off on the fifth to seventh day. When catgut is used to unite the skin, the first dressing may be done anywhere from the tenth to the fourteenth day. By then the part of the suture in contact with living cells will be absorbed; the rest can simply be brushed away.

To remove a stitch, seize one of the loose ends and draw upon the knot so that a little of the buried part of the suture is drawn out of the skin; cut this with the barely opened points of a sharp pair of scissors. A quick jerk removes the stitch with practically no pain.

Michel clips are unbent by seizing each half with one of a pair of mouse-tooth forceps and pulling them apart. Single hooks may be used instead of the forceps.

It has been stated that Michel clips give rise to pain and local necrosis more readily than sutures. This is true if the clips are applied too tightly; the same objections can be made against sutures which have been too tightly drawn. In both cases localized necrosis is bound to ensue, and the patient suffers more pain than if the skin were less tightly constricted. Ochsner has laid particular stress upon this point. He sutures his skin wounds with horse hair because of its elasticity. He states that he has never seen any necrosis or cutting through of sutures when this material was employed. In his clinic the approximation sutures are so loosely passed that the horse hair arches over the line of union and does not come in contact with the skin except at the points of entrance and exit; it is stated that the subsequent reactive swelling of the tissues fills up the loops.

If dried secretions have matted the layers of gauze together, its removal requires especial care, for a sudden careless tug may tear apart the freshly agglutinated margins of the wound. It is best to raise one corner of the mass gently, and grasp the flat piece of gauze next to the skin [1] with a forceps or other instrument capable of holding it firmly in place. The superficial layers of gauze are now removed. Considerable force can be used without dragging on the freshly healed tissues. On either side, the skin is gently separated from the overlying gauze up to the suture line, and, beginning at one end of the wound, the gauze is pulled off. **The direction of pull is always longitudinal.** It is well to keep the skin in place by pressing it down, as this lessens the pain. (The use of peroxid of hydrogen to loosen dried gauze is not very effective. It is better to remove the superficial part of the dressing and apply a wet dressing for half an hour. By that time the dried gauze has had time to soften.)

The instruments used in removing the gauze must be discarded. As said below, only after the wound itself has been exposed should sterile drapings be spread.

After the use of the actual cautery upon skin lesions, leave the scab alone until it separates at the end of about 10 days. The small granulating area which is usually left behind is treated according to the principles laid down under the heading of ulcer.

Do not remove a scab without good reason! If a lacerated wound has become crusted over and there are no signs of purulent inflammation, such as swelling and widespread redness, or increased pain, leave it alone. The scab is the best occlusive dressing imaginable, it is nature's collodion.

This point is of less importance in postoperative treatment than in the management of accidental wounds. Large and small lacerated wounds do better if left alone in the absence of signs indicating retention than if subjected to daily dressing. Astley Cooper was the first to observe this in the case of a crushed ankle. The dried, blood-soaked dressings were left untouched for several weeks and the wound healed kindly and without suppuration under this unsightly covering.

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[1] Instead of applying loose gauze directly to the wound's surface (after operation is completed), for the sake of convenience at the first dressing, a small flat piece of gauze which a little more than covers the suture line is first applied and then the rest of the dressings are applied in the customary manner.

Subcutaneous Serous Effusions.—TREATMENT.—Subcutaneous serous effusions are not rarely seen at first dressings of perfectly aseptic wounds. There have been no fever and no unusual pain; at the dressing there is no redness of the skin, the wound of which has healed, merely a fluctuating swelling corresponding with the region of the wound. Under the strictest aseptic precautions and after painting with iodin, a narrow bladed instrument—the flat end of a probe, for example—is inserted through the freshly healed scar until the fluid is reached, and the wound is cracked open a little more to permit of freer drainage. The instrument is laid aside and a firm compressive dressing is applied. The amount of secretion determines the subsequent course. If it is scanty, there is no need of disturbing the wound for 2 or 3 days; if copious, the dressings must be renewed as often as they become saturated. Usually the wound closes promptly as soon as the serum has escaped.

PREVENTION.—Many operators like to squeeze out the air just before closing the last stitch of the skin wound. They then apply hard pads of gauze to either side of the suture line for the sake of additional compression.

ELASTIC COMPRESSION is a prime factor in preventing the subcutaneous accumulation of serum. Loose gauze adapts itself for this purpose most readily. It equalizes the pressure of the overlying bandage. Where direct compression is desired over one particular spot, a folded towel or a roll of bandage may be used, held in place by a strip of adhesive. Over this the usual bandage or binder is applied.

DRAINAGE OF ASEPTIC WOUNDS is often made to permit escape of serum for the first 48 hours.[1] It is then removed under the strictest aseptic precautions. Under no circumstances are swabs or probes to be passed into such tracts after withdrawal of the drainage. There is no more sense in doing this than in probing a fresh gunshot wound. In either case there is great danger of carrying infection inward.

Consistent Aseptic Technic.—Consistent aseptic technic is rarer in the wards than in the operating room. It is quite common to see a surgeon pull on a pair of sterile gloves in the most approved fashion and then remove the dressings (the outside of which has been in contact with the bed clothes, etc.) with these sterile gloved hands. Often before the dressings are touched, a sterile towel is spread out with religious care; then, as the dressings come away, they usually sweep over that part of the towel nearest the wound, infecting it. Next, sterile scissors and forceps are used for removing stitches—it is always a matter of chance whether or not the points of these instruments become infected. Usually they do not, but this through no fault of their user, who is, of course, unconscious of the errors committed. One of the most frequent "breaks" is the contact of shirt- or coat-cuff with towel, cotton, or gauze wipes while instruments are being used in a wound. As attention is concentrated on the wound, this contact escapes notice.

Perhaps if something like the following sequence were to be observed, there might be less opportunity for error, though if a man does not have the true sense of asepsis, no set of rules can give it to him.

[1] This is a routine measure in breast amputations, extensive thyroidectomies, amputations of limbs, accidental scalp and face wounds, etc.

Remove all dressings except the last piece of gauze next to the wound, without, of course, touching the wound. Now, with the wound exposed or covered with a single piece of gauze, the surgeon should turn back his cuffs or, better, roll up his sleeves before pulling on the gloves in the customary approved fashion (see Vol. I, Chaps. I and II). Finally, the sacred sterile towel can be spread so that it lies up close to the wound.

The reader may remark that there is nothing new in all of this, a fact which I most readily concede. But I do insist that the men of the pre-antiseptic and pre-aseptic eras and many of those trained by them do not possess a sufficiently acute sense of asepsis. All which has been said about the clinics abroad, and the "breaks" which occurred in so-and-so's clinic, is true enough, but we should not boast as long as infections follow Lane platings in clean cases, or distinguished operators grasp the railing of the amphitheater, adjust horn spectacles or revolving chairs, wipe their hands with towels hung around their necks, or pull a badly narcotised patient's tongue forward **and then go back to their operating without more ado!**

As in religion, everyone makes loud protestations of faith, but how long will the average operator bear the statements of a conscientious and tactless "censor of asepsis," without showing annoyance or even losing his temper? Nurses are even worse in this respect; to call their attention to a "break" is to earn their everlasting hatred (for the time being).

The question is not how to become surgically clean, but **how to stay so.**

Binders.—The function of a binder is to take the place of a bandage in securing the dressings in place. Yet how often does one see failure in accomplishing this purpose! Many binders put on in the operating room are **applied too tightly**; the unconscious patient offers no remonstrance, and as consciousness returns his complaints are attributed not to the unnecessary tightness of his dressings, but to the unavoidable pain in the wound. Simply sliding the fingers under the edge of the binder will tell one whether it is too tight. Another frequent fault is that **more of the body is confined by the binder than is really necessary.** For example, after an operation upon the lower abdomen, it is not necessary that the binder shall constrict the upper abdomen and thus hamper the play of the lower thorax; nor, after a gall-bladder operation, shall the lower abdomen be tightly encased, hampering the abdominal respiratory movements.

On the other hand, too loose application of a binder results in its displacement. Binders tend to migrate toward the narrowest part of the trunk, namely, the waist. Hence, those applied over the hips and lower abdomen should be kept from sliding upward by 1 or even 2 perineal straps padded with cotton to prevent cutting; while those binders around the thorax or upper abdomen should be kept from sliding downward by shoulder straps.

Much time is wasted in some institutions in putting an unnecessarily large number of pins into binders for the sake of a pleasing appearance. At the Mayo Clinic one can see binders in their proper place doing their work by virtue of 3 large safety pins. Of course, the many tailed or scultetus binder is capable of more accurate adjustment than the other sort.

It is always safer to place a strip of adhesive plaster half on the gauze and half on the skin at the upper and lower margins of the dressing to prevent its slipping. In fact, some suggest discarding binders entirely and using 3 or 4 strips of adhesive plaster run half or three-quarters around the body.

Adhesive Plaster.—At a first dressing it is wrong to tear off that part of the adhesive which is firmly adherent to the skin. If the dressings are soaked with secretions, the plaster is cut just at its union with the skin on either side, and the mass of soiled gauze can be removed in toto. If, however, the superficial layers of gauze are still clean, the adhesive need only be divided on 1 side, so that the dressing is laid aside as though on a hinge. After the deeper parts have been renewed, the original superficial part is again swung back into place and secured by short pieces of fresh adhesive.

In cases where the dressings require frequent change it is of advantage to use tags of adhesive plaster applied to the skin well over on each side beyond the dressings. From these tags, tapes run across the dressings to meet each other. Simply untying them releases the dressing; should the tapes become soiled, it is easy enough to renew them without disturbing the adhesive.

In short, adhesive plaster, once firmly attached to the skin, should not be removed except for good and sufficient reason. Repeated removal and re-application render the skin raw and tender. It is far better for the patient to look like a neglected bill board, with a mass of superimposed layers of adhesive, than to present a neat appearance at the sacrifice of his personal comfort. When finally it comes time to remove the adhesive, the liberal use of benzin or commercial ether, combined with an unhurried, gentle manner, will assure minimum irritation to the skin.

Rupture of the Primarily Healed Suture Line.—This accident may occur in asthenic individuals. The locality of the wound or the method of closure has practically nothing to do with its occurrence. There are certain people whose tissues are of poor quality and, no matter how one unites the wounds of these persons,[1] there is danger of rupture. In abdominal surgery, the cases of carcinoma of the stomach and uterus seem especially prone to this accident. It usually happens between the fourteenth and twenty-first days. A cough or sneeze may be followed by parting of the wound. Sometimes the peritoneum remains intact, at others the entire wound ruptures, allowing prolapse of viscera. Inspection of the wound shows not the slightest reaction. The unchanged tissues are as clearly to be recognized as at operation.

The accident is not usually followed by serious consequences. A secondary suture is made and the wound heals without further trouble.

INFECTED WOUNDS

The general principles in the treatment of infected wounds consist in (1) providing free drainage and (2) improving the patient's general condition by every possible means.

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[1] Whether by layer or through-and-through suture, or by silk, catgut, or linen.

Wounds Infected from the Very Beginning.—As a matter of course, these should not be closed until suppuration has subsided. If the margins can then be brought in contact by adhesive strapping, well and good. If not, it may be necessary to mobilize the edges by undercutting before uniting with secondary sutures, leaving plenty of space between the sutures for drainage.[1] Should the defect be so large that the margins cannot be brought together, some suitable plastic measure must be resorted to.

Wounds infected at operation should be opened widely from one end to the other to afford free discharge of secretion, and only after they have become lined with healthy granulations should attempt at secondary closure be made.

An exception to this rule exists in wounds of the face, where, if it is possible, an attempt should be made to drain at 1 or 2 points for the sake of the cosmetic result. Under such circumstances, of course, a much closer observation must be maintained to guard against retention and the wound must be inspected several times a day.

In cellulitis of a particularly malignant character there may be a great deal of redness and very little secretion. On the other hand, there may be little redness or swelling with much secretion.

Late Infection.—Catgut infection and stitch-hole abscesses come on late. In the case of stitch-hole abscesses, if the approximation line is well united, and there is no general reaction, remove the stitches, apply a wet dressing, and watch for 24 hours before doing anything more. If, on the other hand, the approximation line is inflamed and the adjacent tissues are swollen, red, and tender to pressure, it is better to open the entire wound rather than risk the effects of retention.

Bacteriemia.—The essential treatment of patients whose blood shows the presence of bacteria consists in searching for and freely draining the local focus or foci of infection. It is wrong to suppose that a patient whose postoperative blood-culture is positive for a certain pathogenic organism is doomed. It is not uncommon to observe a bacteriemia just before and after operations which save the patient's life; while the first culture taken a few hours after the operation may also show some organisms, later ones usually are sterile. This is seen in many cases of acute mastoid disease, osteomyelitis, and uterine infection. Even if organisms persist in the blood for some time, there is a possibility of eventual recovery, especially if the relative numbers do not increase. Meanwhile the patient's strength should be conserved and maintained in every possible way. Patients with sepsis often show great capacity for food. This should be indulged in; it is the best means of affording the individual ammunition for his fight against the bacteria—far more useful than inunctions of unguentum Credé or the injection of vaccines.

Drainage Material.—Except to keep the mouth of a wound open or to stop a hemorrhage by compression, gauze should not be used in the depths of a wound. It becomes saturated very quickly. It then ceases to drain and acts as a plug even if loosely inserted. Besides this, its removal always causes the patient a great deal of pain except in old wounds. The intelligent employment of rubber, either as rubber dam or as rubber drainage tubing, will provide for the free outlet of purulent discharges. It has the additional advantages that the surgeon spends much less time at dressing the wound, and that the patient is spared much unnecessary pain.

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[1] Reichel advises secondary suture of all scalp wounds as a routine measure.

It is important to preserve a nice balance between removing drainage too soon, thus allowing the superficial parts of the wound to come together and blocking the outflow of pus from the depths, and, on the other hand, leaving the drainage material in place too long, which results in the formation of a rigid-walled sinus the sides of which will not come in contact with one another. Its lining of granulations is of such poor quality that there is little or no response to stimulating measures. Such a tract may remain *in statu quo* for an interminable length of time before it closes. If all other measures fail, excision of the tract is the only remedy.

By gradually shortening the drainage tubing day by day, there is less likelihood of experiencing retention from too rapid withdrawal of drainage. If 2 large tubes are lying parallel to one another, withdraw 1 entirely after 2 or 3 days, gradually shorten the other, and finally pass a narrow tube inside what remains of the larger tube before withdrawing it. In this way the patient is spared unnecessary pain, although the drainage loses nothing in effectiveness.

Needless to say, a safety-pin should transfix the outer end of any drainage material which is used. Neglect to observe this precaution frequently results in the unobserved disappearance of the drainage material within the suppurating tract, and its rediscovery months later at a second operation by another surgeon.

Drainage by Gravity, Counter-incisions, and Permanent Suction. Escape of secretions by gravity may be facilitated by changing the position of the drained part (in an appendicitis abscess having the patient lie upon his right side) or by establishing a counter incision. If anatomical or other conditions do not permit either of these, permanent suction (Vol. I, Chap. VII) may be employed. If, in spite of these measures, the wound does not look well, the temperature keeps up, and there are no symptoms pointing to disease elsewhere, it may be assumed that badly drained or unopened cavities still exist in the affected region and search for them must be made without further delay.

Irrigation of wounds is falling into disuse as time goes on. As long as no retention exists, the tissues will heal as rapidly as their individual nature allows. Nothing is to be gained by washing out a wound which, within 15 minutes, fills with purulent secretions. This remark does not apply to permanent irrigation of infected joint cavities, etc., but merely to the use of irrigation as a routine measure in the round of ward dressings.

Permanent Bath.—In certain infections of the hand and forearm, of the ischiorectal region, and of the lower extremity, permanent bath at body temperature or a little higher (up to 116° F.) may be of great service in cleansing the parts without pain, affording ready escape of secretions and permitting (in the case of the extremities) moderate movements. The pus-infected water of the permanent bath should be mixed with some strong antiseptic before it is poured into the sink. The nurse or orderly whose duty it is to attend to this should be cautioned against coming in contact with this septic material. The composition of the permanent bath is of minor importance. Weak antiseptic (boric acid or aluminum acetate) solutions are employed.

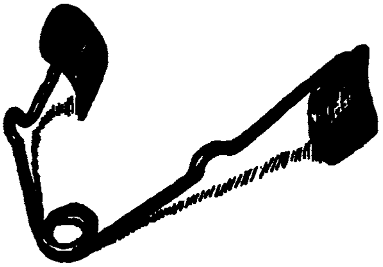

FIG. 8.—TIEGEL'S SPRING DRAIN.

Drainage in Minor Surgery.—Tiegel (11) employs a spring to keep the lips of the wound apart, thus facilitating drainage (Fig. 8). Other authors have employed stay sutures to keep the margins of the wound apart to permit of free drainage of the subcutaneous region without the use of a drain.

Heat.—Heat may be applied in any number of ways. Among the easiest are the poultice and the hot-water bag. I shall not enumerate the thousand and one devices for diathermy. Let it suffice that a very simple and convenient apparatus may be improvised by lining a box with asbestos cardboard upon which are set up as many electric bulbs as desired. At opposite ends, the box may be cut away to suit the individual requirements of the case.

Types of Absorbent Dressing and Indications for Their Use.

In a properly drained wound one finds all the secretion in the superficial dressing and practically none in the wound itself. The welling up of pus upon removal of dressings shows that this purpose has not been accomplished. Either the wound has not been properly drained or the dressings have not been changed often enough.

Where the secretion is thin and profuse, it is unnecessary to use a wet dressing. There is so much fluid given off by the wound that the dressing rapidly becomes soaked and must be frequently changed. Under such circumstances, the employment of *pads of Irish moss* in gauze envelopes instead of quantities of dry gauze is of distinct economical advantage. Irish moss comes in flat boards like thick cardboard. This is cut into convenient sizes and is wrapped in 2 or 3 thicknesses of gauze. It is then soaked in water until it becomes soft, is wrung out thoroughly, and applied to the wound—under proper aseptic precautions.

Where the secretions are thick and fairly profuse, a *wet dressing* changed 2 or 3 times a day should be used. For all around usage aluminum acetate solution (liquor burrowii) is the most satisfactory. Only the supernatant fluid of the aluminum acetate should be used. The sediment should not be shaken up; it is an inert, insoluble compound (sulphate of lead).

Experience will show how much gauze is necessary to properly absorb the secretion of any given wound. The gauze should be wrung out before it is applied to the wound. A split compress protects the skin from pressure of the safety-pins holding the drainage in place. Rubber tissue, oiled muslin, oil silk, or wax paper covers the wet gauze and projects beyond it on all sides. (This is a technical error in my opinion. EDITOR.) This is held in place by a suitable bandage, binder, or tapes, as the case may be.

In wounds with moderate secretion, in which the acute inflammatory stage is past, one can obtain absorption of secretions and at the same time avoid undue maceration of the skin by applying a dry gauze dressing covered with rubber tissue or some similar impervious substance; this prevents crusting in the superficial part of the dressing. Later on a dressing of bland ointment suffices. The treatment of granulating surfaces is described below under Ulcer.

Protecting the Skin from Irritating Secretions. During the stage of acute suppuration, coating the adjacent skin with zinc oxid ointment not only protects the skin from irritation, but also prevents the gauze from becoming glued to the skin. Where the wet dressing has set up a folliculitis of the adjacent skin, simple exposure to the air often cures it. If not, a wet dressing of 50 per cent. alcohol may improve matters.

Furuncles. It is often possible to cause a beginning furuncle to subside by the application of a small bit of 10 per cent. soap salicylic plaster (the imported German variety is the best). The plaster should be changed once or twice a day. Under no circumstances should the pus be squeezed out of any furuncle. Such manipulation may result in a spread of the process and the formation of a carbuncle. If the salicylic plaster is not available, a wet dressing should be worn until the signs of inflammation have subsided. If there is not much swelling or inflammation of the adjacent skin, a small bit of surgeon's lint, the size of a postage stamp, may be spread with a little ointment and held in place by very narrow strips of adhesive plaster. Do not try to hasten the sloughing of a furuncle. As long as there is no retention, leave the slough alone until it becomes separated of itself.

Certain men introduce a toothpick dipped in carbolic acid into a furuncle. The use of tincture of iodin for this purpose is nearly as effective and much less apt to be followed by necrosis. Before opening any focus of suppuration (furuncle, carbuncle, paronychia, etc.) it is an excellent plan to anoint the adjacent skin with some sort of grease, so that the escaping pus does not infect adjacent hair follicles and give rise to further trouble. If no grease is available, soap will answer the purpose.

Removal of Gauze from the Depths of a Wound.—If possible, it is well to wait until the gauze has become loose of itself before removing it; one may have to wait as long as 2 or 3 weeks for this to happen. If, however, it is imperative that gauze shall be removed sooner than this, the following points should be borne in mind:

(1) Soaking the superficial gauze by a superimposed wet dressing, for half an hour or so, or the application of peroxid for 10 or 15 minutes, will loosen the gauze for about an inch from the surface.

(2) Undue force must never be employed in pulling the gauze loose. Spread out each piece of gauze in turn, testing the center and either margin to see which part will come away most easily. Pull up such portions as yield readily until resistance is met with, then go over the entire mass of gauze piece by piece, and probably much which could not be removed previously can now be withdrawn. If several strips have been withdrawn and the remainder are firmly adherent, transfix them close to the skin with safety-pins, cutting off the redundant ends, then apply a wet dressing for 24 hours before again attempting their removal.

(3) Twisting a piece of gauze into a rope may sometimes free it when pulling alone fails, but here, too, one must be careful to avoid using too much force.

Whenever it is possible, it is best to leave the gauze in place until it has become loosened of itself. This is especially important where gauze has been used to stop a secondary hemorrhage or where it leads down to the suture line of a hollow viscus.

The Treatment of Ulcer

Granulations.—*Healthy granulations* should be a bright strawberry red, dense in structure and should bleed readily. *Exuberant granulations* are pale and flabby, and tear easily. These may be cut off with a curved scissors or curetted away with a sharp spoon or cut down with a silver nitrate stick. The application of a wet dressing of red wash for 24 hours will cause a remarkable shrinkage in the exuberant granulations. *Insufficient granulations* require *local stimulation* by means of balsam of Peru, a wet dressing of nitrate of silver solution, 1:500, application of 50 per cent. silver nitrate stick or of full strength silver stick. In addition, attention should be paid to general hygienic measures.

In some cases there is a tendency for a fibrin deposit to cover the surface of the ulcer. This can readily be prevented by the use of a wet dressing of 3 per cent. citrate of soda solution.

The surface of the granulations, once they have become healthy, must be kept smooth by the use of tin foil, silver foil, aluminum foil, or strips of rubber tissue, applied partly over the epithelial margin and partly over the granulations, well greased gauze, lintine or adhesive plaster straps.

An excellent dressing for the margins of ulcerating surfaces and also a good substitute for flexible collodion dressing to small wounds, especially those of the face, is the following:

℞	40° paraffin	6 gm.
	52° paraffin	18 gm.
	Beeswax	2 gm.
	Castor oil	1 c.c.

To be sterilized in an autoclave and applied with a camel's-hair brush while warm.

I am indebted to Dr. Alexis Carrel for this prescription.

Stimulation of Epithelial Margin.—The epithelial margin of an ulcer may be stimulated by an 8 per cent. scarlet red ointment. This ointment should be applied to the epithelial margin direct and to no other part of the ulcer. The stimulating effect of scarlet red and its allied amido-azotoluol varies greatly. In some cases there seems to be a remarkably rapid proliferation of the epithelial cells, while in others no noticeable effect can be observed. Unless very large amounts of this are used, the danger from anilin absorption is nil. **Scarlet red has no stimulating effect upon granulations.**

Plastic Procedures and Skin Grafting. Large granulating surfaces must be healed by a suitable plastic procedure or by skin grafting. The margins of the adjacent skin may be mobilized by undercutting. If the defect is not too large, it may be possible to bring these mobilized margins together by means of silkworm gut stitches. The angles of the wound should be drained with small pieces of rubber tissue. For the details of covering defects with flaps from other parts of the body (Italian method), the Krause and the Thiersch method, see Vol. I, Chap. XII. J. S. Davis does not curet the granulations, but places his grafts directly upon the healthy granulating surface. In large Thiersch grafts or in Krause full thickness grafts, he establishes numerous button holes to provide for drainage of secretions from the granulating surfaces; this prevents lifting the grafts away from the underlying granulations by accumulations of purulent secretion. He holds the graft in place by means of a rubber covered cotton mesh, which is firmly attached to the healthy skin beyond the granulating surfaces. This permits a frequent change of dressing without danger of shifting the grafts.

Care of Adjacent Skin and Joints. In ulcer, as in deeper suppurating wounds, care must be taken to avoid irritation or maceration of adjacent skin. In addition to this, care must be taken to prevent gradual contracture of joints.

Neglect to observe this latter precaution may lead to serious consequences. Thus I have seen a contracture of the knee-joint following the incision and drainage of a popliteal abscess. A thick cicatricial deposit surrounded the vessels and nerves and resisted all attempts at gradual extension. The knee was flexed beyond a right angle and, in order to give the patient a useful limb, it was necessary to resect a perfectly healthy knee-joint.

Erysipelas, pyocyaneus infection, diphtheria (in wounds), and tetanus, are treated in Chapter XVI, Volume I.

SPECIAL FORMS OF INTOXICATION

Carbolic Acid.—Carbolic acid is not to be used, even in very weak solutions, as a wet dressing on account of danger of carbolic gangrene. Within an hour, or even less time, the skin becomes anesthetic, shortly after which the superficial tissues suffer permanent damage. The longer the application, the deeper the effect of the poison. If applied early a wet dressing of alcohol may help matters.

In former years carbolic solutions were often used for irrigating large pus cavities, and frequently some of the irrigating fluid was left behind. One of the first symptoms of absorption is the dark brown color of the urine. This is mentioned, though carbolic acid solutions are rarely used at present, because the danger attending their use must be borne in mind.

Pure carbolic acid is still used as a substitute for the actual cautery in disinfecting appendicular stumps, intestinal stumps in the course of resections, and by some in swabbing out abscess cavities (in the latter case alcohol must be used afterward to neutralize the carbolic acid).

In certain clinics carbolic 5 per cent. solutions are still employed for immersing the hands after scrubbing with soap and water.

Bichlorid of Mercury. Bichlorid of mercury is used in 1:2,000 solution for disinfection of the hands and arms; in 1:10,000 strength for gargles and douches; and in 1:500 for final disinfection of the skin after cleansing with soap and water just before commencing to operate.

As a wet dressing it is not to be recommended because of its tendency to cause dermatitis. Upon granulating surfaces it is readily absorbed and may give rise to mild grades of mercurial poisoning.

Iodin.—IODOFORM. Iodoform is still used in certain hospitals. The possibility of iodoform intoxication must always be borne in mind. I have seen several instances in which acute iodoform poisoning (high fever, delirium, etc.) followed the use of a single layer of iodoform gauze stuffed with plain gauze to form a Mikulicz packing after nephrectomy for tuberculous pyonephrosis. The symptoms promptly subsided upon removal of the iodoform gauze.

TINCTURE OF IODIN. Tincture of iodin has recently come into deservedly high favor. It must not be forgotten that it is a powerful irritant to sensitive skins; on these it is wiser before applying it to dilute the full strength tincture by half with alcohol. One should never forget to wash off the surplus iodin after completing any operation in which it is used. Failure to do this is often followed at the first dressing several days later by the discovery of diffuse dermatitis with large blebs. In less severe cases the skin is peppered with an infinite number of tiny blebs. On account of its irritating qualities, tincture of iodin should not be used.

Scarlet Red.—Scarlet red is an anilin dye used for its stimulating effect upon the growth of epithelium. It should, therefore, be applied to the margins of a granulation wound and not upon the granulations (see page 55, Stimulation of Epithelial Margin).

Nitrite poisoning has followed the use of large amounts of Beck's paste in suppurating tracts.

Rashes after operation may be due to a variety of causes, among which may be mentioned administration of calomel, turpentine in enemata, simple soapsuds enemata, cubebs, the virus of scarlet fever, finally urticaria from manifold causes.

Alcoholic Delirium (Delirium Tremens). For the routine treatment of this disease, the reader is referred to standard text-books on therapeutics. I shall merely speak of the preventive measures. It is a mistake to deprive a chronic alcoholic of his customary tipple just because he happens to be in a hospital. Not only should alcohol be freely given within the limits of discretion, but some strong sedative (preferably paraldehyd ʒss) should be administered at suitable intervals. If, in addition to this, a plentiful diet is allowed and the bowels are kept open, the risk of dementia potatorum will be minimized. It may be of interest to add that a chronic alcoholic will take his anesthesia far better if he has been given a stiff drink of whiskey a short time before.

Acute Postoperative Mania. Acute postoperative mania may come on as soon as the patient has recovered from narcosis. Fortunately, struggling, getting out of bed, walking downstairs, etc., are not apt to be followed by injury to the wound if these acts occur within a few hours after operation. The freshly inserted suture material is at its strongest, and, as a rule, no serious consequences follow. In general the condition passes off within a few hours. Its continuation beyond this time is of the gravest prognostic import. In outlining therapeutic measures, one must search for some underlying cause, such as acute nephritis, acute degeneration of the liver or a meningitis, as well as an inherent disposition to insanity.

Chronic postoperative psychoses until now have been of less importance, but with the advent of Employers' Liability Compensation laws in this country, it becomes of the first importance for the surgeon to detect simulation, an art which the Germans have brought to a high state of perfection. The treatment is hygienic and psychiatric.

THE SKIN

Scars.—Normally, a fresh scar is of a light red color, which fades to a silvery white in the course of several months. It is then distinctly whiter than the normal skin. The more accurately the incision corresponds to the folds of the skin and the more carefully the skin is united after operation, the less apparent will the resulting scar be.

RECENT SCARS.—Recent scars have a tendency to spread, i. e., to yield to constant strain. There is more tension on scars which run longitudinally than on those which run transversely to the long axis of the body. A scar which is linear at the time of the first dressing, often spreads to a width of 2 or 3 mm. at the end of a few months. Certain operators lay special stress upon the accurate suture of the platysma to prevent widening of scars of the neck. While there is no harm in suturing the platysma, it is of far greater importance, whenever possible, to place all incisions in the depth of the transverse folds of the neck.

OLD SCARS: CICATRICIAL CONTRACTION.—As it grows older, every scar tends to contract. The larger the mass of scar tissue the greater is this tendency.

Plastic Operations.—In plastic operations (see also Vol. I, Chap. XII) the ability to gauge the ultimate amount of cicatricial contraction is absolutely essential. It can only be acquired through a large amount of practical experience. The immediate effect of a plastic operation is never the same as the final result. The more important the cosmetic effect, the longer should one wait between operations. Lexer waits from 6 months to a year or even longer before undertaking a second operation. For plastic operations upon other parts of the body than the face, it is unnecessary to wait so long.

Edematous swelling of a transplanted flap subsides in the course of time; unless this is extreme, compression is unnecessary.

The excision of large, disfiguring scars may be done where the adjacent skin is freely movable. However, one should wait until the scar has undergone maximal contraction before attempting excision.

The subcutaneous interposition of fatty tissue or of subcutaneous connective tissue is supplanting paraffin injection for cosmetic purposes. Fat is now used to prevent adhesion of skin to underlying bone after operations for chronic osteomyelitis, to fill out defects in sunken-in spots in the face, and to prevent adhesion between the skin and underlying tendons or nerves.

AFTER-TREATMENT OF PLASTIC OPERATIONS ACCORDING TO THE ITALIAN METHOD.—By this method a defect in one part of the body is almost completely covered by a pedunculated flap from some other convenient part. When, in the course of time, the flap has healed into place, its base is cut across, either a little at a time or, if it is well nourished, in 1 step. Thus, the skin of the arm may be used for closing defects of the face, that of the breast or abdomen for defects of the hand and finger, and that over the calf for defects upon the heel or shin of the opposite leg. The individual ingenuity of the surgeon has free play in devising suitable means for absolute fixation of the parts as well as guarding against decubitus. For a few days before the bandage is applied, it is well for the patient to sleep in the attitude of future fixation. Thus, if the arm is to be approximated to the face, a light bandage should maintain this attitude during the night. As a rule, plaster of Paris is most convenient for maintaining fixation. Skin surfaces which otherwise would lie in contact with one another and give rise to disagreeable odors, should be separated by well-powdered layers of cotton or gauze. It is better to cover the raw, sterile surfaces near the base of the flap with a generous supply of sterile boric acid ointment before applying gauze dressing. Plaster bandages should be so arranged that the wound is accessible for inspection and dressing. At the end of 10 days to 2 weeks, the base of the flap should be divided. The treatment of the wound is that of any granulating surface. Joints which have become stiff by immobilization will regain their normal state within a week or 2. The patient should be encouraged to use them within the limits of pain.

The transplanted flap never acquires the same color or the same acute sensation as that of the normal skin, also it is less resistant to injury.

OPERATIONS UPON THE BLOOD-VESSELS[1]

After ligature of large arterial stems in people whose vessels were previously healthy, there is grave danger of the death of tissue in the area normally supplied by the ligated vessels. Where, however, a local obstruction has previously existed near the point of ligation, complete stoppage of the circulation is less apt to be followed by serious consequences because the presence of this obstruction has led to the development of collateral circulation. To prevent circulatory disturbances after major operations, where a large arterial trunk must be tied, Halsted has devised aluminum clips which before operation gradually narrow the arterial lumen, thereby encouraging the development of collateral circulation.

The best position after ligation of a large arterial stem is slightly above horizontal. After ligation of a large venous trunk, the limb should be vertically suspended. It should be kept quiet and warm. If the heart's action is weak, it should be stimulated. The swelling after ligation of a large venous trunk gradually subsides as the collateral circulation develops.

Postoperative Thrombosis. The various operations for aneurysm always involve the possibility of thrombosis or of embolism. For a consideration of this condition, see pages 12 and 13 of this chapter.

I know of one case where ligature of the external carotid was followed a few days later by embolism of the internal carotid. The thrombus had extended backwards from the point of ligation, had projected into the bifurcation of the common carotid, and had been broken loose from this point and carried upward toward the brain.

OPERATIONS UPON THE LYMPHATIC SYSTEM

Wounds of the thoracic duct are mentioned under Thorax and Neck. Lymph stasis after excision of lymph nodes is treated in discussing amputations of the breast. (See next chapter.)

OPERATIONS UPON THE PERIPHERAL NERVOUS SYSTEM[2]

Nerve Suture (Including Grafting of Nerves). Primary union, that is the regaining of function within a day or 2 after operation, has been repeatedly

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[1] See also Vol. I, Chaps. VIII and IX.
[2] See also Vol. I, Chap. XIII.

described, but is so exceptional that it cannot be counted on. The part should be immobilized in the position of maximal relaxation. Function begins to return between 3 to 6 months or later, and improvement continues over months or even years. Sensory function returns before motor. There are so many anastomotic communications between the sensory nerves (any given part is supplied by 3 segments of the spinal cord) that return of sensation does not prove return of function in any given nerve. Consequently, after division of a mixed motor and sensory nerve, one cannot speak of returning function until signs of motor activity begin to appear.

As a rule, the sooner an injured nerve is repaired, the better the prognosis, though exceptions exist. Excellent results have, nevertheless, been recorded following operations from 3 to 6 months after injury.

The statement that implantation of a motor nerve into the belly of a muscle will be followed in 4 weeks by recovery of function is too recent to be accepted without reserve.

Neurolysis.—Paralysis of a nerve due to pressure by callus, a scar or a dislocated bone, is usually recovered from within a few weeks after removal of the cause. The time required for restitution of function will depend upon the degree of trauma inflicted at the time of injury.

Neurotomy and Neurectomy.—After neurotomy or neurectomy for neuralgia, the same pains for which the operation was performed may persist for a day or 2 and require the administration of large doses of morphin.

OPERATIONS ON THE TENDONS[1]

Tenorrhaphy.—The limb should be immobilized in the position of maximal relaxation. As soon as the cutaneous wounds are healed, motion should be begun. Infection almost always means failure of the operation. One must then wait until suppuration has subsided and the wound has healed over before renewing the attempt.

Tenotomy.—The small wounds made by tenotomy should heal without further complication. The after-treatment is orthopedic.

Operations for Tuberculosis of Tendon Sheaths.—After operation for tuberculosis of the tendon sheaths, as soon as primary union is obtained, the tendon should be moved. Even if the tendon sheath has been laid wide open and packed with gauze so that the cutaneous scar is intimately adherent to the tendon, the mobility of the surrounding skin allows considerable range of motion. Recently the method of freeing the tendon and surrounding it with fat has successfully prevented adhesion to the skin and other adjacent structures.

[1] See also Vol. I, Chap. XIV.

OPERATIONS ON THE MUSCLES

After suture of muscles, no attempt should be made to use them before the end of 2 or perhaps 3 weeks.

BONE OPERATIONS [1]

Osteotomy for Acute Osteomyelitis. Continuation of fever after osteotomy for osteomyelitis means either insufficient drainage or the presence of a fresh focus elsewhere. The wound of the soft parts should be kept wide open, exposing the diseased bone. (It goes without saying that the opening in the medullary cavity is adequate.

It is impossible at the time of the primary operation to tell how much of the bone is necrotic. If living bone lies at the bottom of the wound, it will soon become covered by granulations, so that the probe, after a week or 2, no longer transmits the sensation of roughened bony surface to the surgeon's hand. On the other hand, dead bone gradually becomes loosened from the living bone (the larger the bone, the longer it takes for the sequestrum to separate). Only when the mobility of the sequestrum is definitely established is it time to enlarge the wound and remove this (secondary sequestrotomy).

In any case the wound must be kept open until the underlying bone is covered by granulation, so that the wound, as a whole, fills up with granulations beginning from the bottom. Should the resulting defective surface be large, healing can be hastened either by mobilizing the edges and making a secondary suture or by covering the granulations with skin graft.

The patient's general condition is greatly improved by ambulant treatment. The patient should get out of bed just as soon as his temperature reaches normal, provided his strength permits. The better his general condition, the more quickly will his tissues react. After operations for osteomyelitis of the femur or tibia or bones of the foot, a good ambulant splint should be applied with a large fenestrum through which the wound can be dressed. This should be done as soon as the acute symptoms have subsided.

In localities where the bone is deeply situated, as, for example, in the thigh, it is important to keep the wound wide open. The least painful way of doing this is to fill the wound with a series of short, wide rubber drainage tubes whose outer ends are linked together by safety-pins. This accomplishes the purpose with far less discomfort to the patient than by means of gauze.

Where much bone has been cut away the limb should be encased in fenestrated non-ambulant splints to prevent fracture.

Adherent Scars.--The dimpling caused by adherent scars to the underlying bone, while of no particular moment in other parts of the body, constitutes a serious cosmetic defect in the face. Active daily massage, while the scar is fresh, may loosen it to a certain extent, otherwise a small plastic operation with liberation of the scar from the underlying bone and the insertion of a small amount of fatty tissue may be necessary.

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[1] See also Vol. II, Chap. VII.

Disturbances of Growth.—Disturbances of growth may follow an osteomyelitis of a long bone. More or less destruction of the epiphysis retards growth. In contrast to this, the presence of inflammation seems to stimulate epiphyseal activity beyond the normal, so that actual lengthening occurs. If then abnormal shortening or lengthening occur in one of the bones of the forearm or leg, the disproportionate rates of growth of the 2 bones give rise to bowing as time goes on.

Chronic Osteomyelitis.—The various methods for filling the defect left behind after removal of diseased bone, Schede's blood-clot, Mosetig-Moorhof's paste, and the implantation of fat according to Makkas, need not be described in detail. The 2 former have not met with success. The latter seems to give more promise than any of the previously devised methods, but it is of too recent origin for exact determination of its value.

Osteotomy and implantations of bone graft are treated upon the same principles suitable for the management of fractures.

PLASTER CASTS.—Plaster casts afford the greatest security in immobilizing the operated limb. The cast should include the joints above and below the point of artificial fracture. The fingers or toes should be left exposed to serve as guides regarding the circulatory condition in the immobilized limb. Immediately after operation the limb is apt to swell. After a few days the swelling subsides, and the limb may shrink away from the cast to such an extent that the fragments are no longer maintained in position. To allow for the swelling, it is wise to split the cast longitudinally as soon as it has been applied, so that in case the swelling is extreme the margins of the split may be pried apart sufficiently to relieve undue pressure without materially disturbing the bony fragments. Later on, when shrinkage begins, another longitudinal split in the cast should be made on the opposite side of the limb to the original cut, converting the cast into 2 molded splints. These can be pared down sufficiently so that by means of a bandage or adhesive straps they closely fit the limb.

As soon as sufficient callus has formed to prevent dislocation of the fragments, the halves of the plaster cast should be removed once or even twice a day, the limb should be massaged and then the cast replaced.

DANGERS OF TOO LONG IMMOBILIZATION.—The dangers of too long immobilization must be constantly borne in mind, and the earliest possible moment should be used for initiating massage and passive motion. This is especially important in joint fractures. When the fracture has reached the stage where the splint can be temporarily removed for the sake of massage, the joint should be immobilized at a different angle each time.

Stimson (10) says: "The fear that prolonged immobilization of a joint would lead to its stiffness is or has been too prevalent, and has led to much untimely passive or active motion of joints that have been injured, and this in turn, by *keeping up the irritation* has increased the stiffness which it was designed to diminish. After the soreness has decreased, about the third week (in dislocations of the shoulder), the patient should be encouraged to try gently to increase the range of motion and freely use the limb within the limit of pain."

When instituting passive motion after immobilization for fracture, the above caution with regard to dislocations should hold for the treatment of the stiffened joint. One must steer a middle course between too little interference, thereby accomplishing nothing, and the application of too much force and trauma, thereby setting up and maintaining a chronic traumatic arthritis.

Operations for Fractures of Long Bones.[1] Lambotte and Lane, the foremost authorities in this field, use as strong fixation apparatus as is possible under the circumstances. A voluminous gauze dressing, but no cast, is applied to the operated limb. At the end of 5 to 7 days, as soon as the skin wound has healed, massage and passive motion are begun. They insist that by this means a *restitutio ad integrum* is reached in the shortest possible time. Their plates and screws constitute true internal splints and effectually prevent displacement of fragments while callus is being thrown out. (See also page 146.)

On the other hand, in this country a large number of surgeons immobilize the operated limbs in plaster casts. They report that plating is invariably followed by more or less delayed union, usually a delay of only 2 or 3 weeks; in a few extreme cases, as long as 4, 5, or 6 months. The long immobilization naturally leads to stiffness of the adjacent joints.

COMPOUND FRACTURES. Certain operators advocate Lane plating for every compound fracture, stating that, as it is, the limb already has an infected wound and that fixation of the fragments by a plate, leaving the wound widely drained, will give a better result than the usual adhesive plaster extension methods. The wound is dressed through a fenestrum in the plaster cast. Since nail extension of fractures has come into vogue, in fractures of the shaft, I see no reason for disturbing the first aid dressing applied by the ambulance surgeon, in which tincture of iodin and sterile gauze have been used in liberal quantities, provided there are no signs of infection. In the absence of fever, if this dressing is left alone and nail extension applied without delay, it is unnecessary to apply any splint whatever to the fractured limb, which is suitably suspended above the bed. At the end of 2 weeks, the first dressing takes place under the strictest aseptic precautions, the surgeon changing his gloves after removal of the dressing and before coming in contact with the wound. The less done to such a wound, the better.

A good coat of shellac to the plaster around the margin of a fenestrum will prevent the cast from becoming softened by being wet with secretion. In the case of a large fenestrum, the soft parts are apt to bulge through the wound to a certain extent, but this is of little importance. I may add that to employ consistent aseptic technic in dressing a wound through a fenestrum which is not quite large enough is an extremely difficult matter.

In badly infected compound fractures of the thigh in which plating has been done, one should be in no hurry to remove the plate. Rather leave it in place and establish counter drainage through the posterior aspect of the thigh. The patient should be gotten out of bed as soon as possible. It is not infrequent to see union take place in spite of the infection. Unfortunately this is not always the case. The screws gradually work loose and pull out, the fragment again becomes displaced, and the plate now lies as a useless foreign body in the depth of the wound, loosely attached to one of the fragments. The removal of it and the screws is a simple matter of enlarging the wound sufficiently to take them out. In such a case the Hackenbruch distraction clamps for separating the 2 halves of the plaster cast at the site of fracture may be of the very greatest use.[1] As infection dies down, consolidation may take place or it may be necessary to reopen the wound and freshen the ends of the bone because of non-union. Meanwhile, long mobilization has resulted in practically ankylosing the knee-joint. Although the patella is freely movable upon the femur, the patient is unable to flex his knee. As a rule, the quadriceps will have become attached to the scar tissue in the neighborhood of the fracture, and this is responsible for the inability to flex.

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[1] See also Vol. II, Chap. V.

DELAYED UNION; NON-UNION.—Before resorting to bone grafting, which is the surest method of curing this condition, rubbing the bony ends together, tapping the site of non-union twice a day for 10 or 15 minutes with a percussion hammer, and injection of 30 to 60 c. c. of the patient's own blood between the united fragments should be given a trial. Maintaining a good general condition and the ambulant treatment of all fractures wherever possible, will afford the best chance for avoiding delayed union.

OPERATIONS UPON THE JOINTS[2]

Rollier Sunlight Treatment.—The Rollier sunlight treatment for tuberculosis of the bones and joints has given such splendid results, and results of such a permanent character, that it should be faithfully tried both before and after operations for this disease. Briefly, the individual is gradually accustomed to exposure of the entire body to direct sunlight, a light hat, a breech clout, and a pair of sandals constituting the entire costume. If it is necessary to wear a cast, the latter is fenestrated so that the solar rays reach and shine directly upon the affected parts. The secretions from fistulæ increase for the first week or 10 days and then gradually diminish until they finally cease.

Arthrotomy.—Following arthrotomy for removal of joint-mice or semilunar cartilages (in the case of the knee), motion can be begun as soon as the cutaneous wounds have healed.

Operations for Old Dislocation.—As soon as the cutaneous wounds have healed, suitable orthopedic measures should be taken for mobilizing the joints.

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[1] The Parkhill clamps, or better, Lambotte's modification of them are also most useful. They assure fixation for 6 weeks and over. Nail extension should not be employed longer than 4 weeks.

[2] See also Vol. II, Chap. VII.

Resection.[1]—The customary positions after resection of the principal joints are as follows: the foot at right angles; the knee in slight flexion (170°); the hip in very slight flexion and abduction; the elbow at right angles, the forearm being midway between pronation and supination.

Padding should be most generous around the bony prominences in the neighborhood of the joints.

It is a general principle that, after any operation upon a limb, the latter should be kept elevated for at least 24 to 48 hours. Suspension from an overhead crane is sometimes the most convenient method for accomplishing this. Unless bleeding is quite profuse do not disturb the dressing immediately in contact with the wound. Apply a fresh compressive dressing and elevate the limb or even suspend it vertically.

After resections upon the upper extremity, the patient may be gotten out of bed as soon as he has recovered from the effects of the anesthetic. In the case of the lower extremity it is wiser to wait a little longer and to be sure that the fragments are in their proper relation to one another and are absolutely fixed in this position by the cast. The cast should be so constructed that no weight is borne by the operated portion of the limb. Attempts to have the resected limb bear weight should be tentatively begun at the end of 4 weeks.

For a long time after operation a light splint should be worn to guard against secondary contracture. This is especially important after resection of the knee. Ingenious orthopedic appliances have been devised for aiding the control of flail joints; want of space prevents their description.

AMPUTATION AND EXARTICULATION[2]

Shock following amputation and exarticulation is largely prevented by perfect hemostasis and blocking of the great nerve trunks several minutes before their division. Lambotte discards the use of the tourniquet. He exposes the main vessels as quickly as possible, after making a skin wound, and ligates them before dividing the bone. He believes there is much less oozing after operating according to this method. A number of men in America are coming to the same opinion both as regards amputation, resection and osteotomies.

After amputation through infected tissues or where there is any doubt about the obtaining of primary union, it is better to pack the stump loosely with gauze and wait until granulations have formed before attempting a secondary suture.

Witzel advocates slight extension upon the dressing covering the stump. He believes there is less chance of marginal necrosis of the flap and that the patient is made more comfortable thereby.

A tourniquet loosely placed close to the trunk assures one of instant hemostasis should bleeding occur at any time.

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[1] See also remarks on Resections in the following chapter under Extremities.
[2] See also Vol. II, Chap. VII.

Necrosis of the stump after operation for thrombo-angeitis in the young and senile gangrene in the old is best avoided by Gritti-Stokes amputation at the knee-joint in the former and at the lower third of the thigh in the latter. The Moschkowitz and other tests for determining the level of amputation are not reliable (Buerger).

After amputations for diabetic gangrene it is common to find that the sugar content of the urine undergoes great diminution.

Neuralgia in the stump is avoided by cutting off the nerves 2 or 3 in. above the point of section of the bone.

Care of the Stump.—There are a number of methods of obtaining good weight-bearing stumps which will be discussed. The modern artificial limbs, however, are so designed that most of the weight is carried by the bony prominences around the joint immediately above the site of amputation. Thus, after amputation through the leg, the flare of the tibia bears most of the weight. After operation through the thigh, the tuber ischii and the flare of the ileum as well as the pubic bone bear the weight, the stump of the limb acting merely as a lever for moving the artificial limb. The osteoplastic amputation of Bier, or according to Bunge, the careful denudation of the lower end of the bone both of periosteum and endosteum and marrow for at least an inch or two, are good methods for obtaining a sound stump capable of bearing weight.

Hirsch's method for making a leg stump tolerant of pressure is as follows: Following healing of the cutaneous wound, the patient is kept in bed. With the stump enveloped in cotton, the patient is instructed to press intermittently against a wooden box of suitable size placed at the foot of the bed as if walking upon the stump. The movements at first are very gentle and are to be increased in strength as time goes on. This should be kept up from 5 to 10 minutes, at first 3 times a day, later on 4 times a day, then every 2 hours, and, lastly, every hour. After the completion of this so-called walking exercise, there should follow a 2 to 4 minutes' active flexion and extension of the knee and hip, after which the stump is placed at rest in elevation. When a fair degree of tolerance has been reached, it is no longer necessary to use the cotton-wadding cover. During all this time, the stump should be massaged carefully twice a day in order to make the soft parts overlying the stump as movable as possible. Within 2 to 3 weeks, the patient is able to bear his entire weight upon the stump. By continuation of these exercises, the skin becomes thick and calloused, and forms a veritable sole. It is better to wait from 3 to 4 months before fitting an artificial limb.

After amputation according to Lisfranc or Chopart, or after the method of Pirogoff, no special apparatus is necessary.

The development of a conical stump indicates re-amputation. This is to be expected after amputations in young children.

Artificial Limbs.—The manufacture of artificial limbs has reached a high state of perfection. The various acts wearers of artificial limbs were able to perform before the last International Surgical Congress were most astonishing.

SINUSES

Diagnosis is essential for the intelligent treatment of persistent sinuses. Besides local examination of the tract (probing, microscopical examination of granulations, and bacteriological examination of secretions), the general condition of the patient must receive attention.

Probing.—The principles of probing are concisely given by William F. Fluhrer (1) as follows:

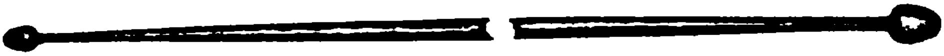

Fig. 9. Tempered Aluminum Probe (Fluhrer.)

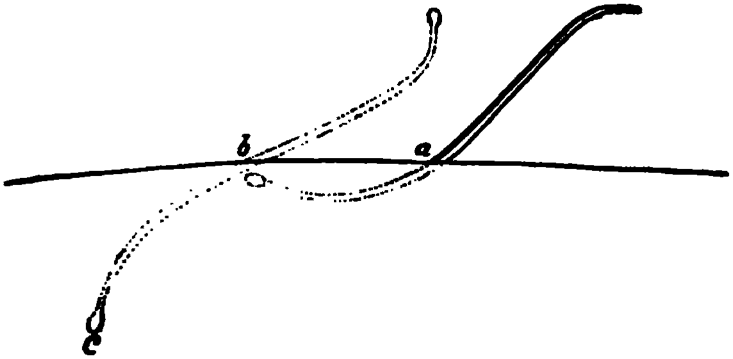

Fig. 10.—Method of Using a Bent Probe for Exploring Tortuous Tracts. (Fluhrer.)

> "In probing a wound it is essential that the end of the exploring instrument shall be of such a size as not easily itself to wound the tissues and make a false passage. The end should therefore be large. Not only does a large extremity to the probe save the tissues from injury and diminish the chance of making a false passage without the exercise of an undue amount of force, but the large end, even when it is beneath the surface of the body, is easily discoverable by palpation or dissection. In probing a wound to learn its course, depth, and other features, we should be able to follow or infer with exactness, from the exposed portion of the instrument, the varying positions of its buried end. It is further essential, therefore, that the end shall hold a fixed relation to the shaft, or, in other words, that the probe shall have sufficient rigidity to hold a given shape. This rigidity is requisite to the practice of another procedure to determine the location of the exploring extremity—namely, conjoined manipulation through the medium of the probe. The shaft of the probe should not only be rigid, but should also have a considerable bulk, that a large surface may be in contact with the fingers and subject to the informing touch. Finally, the probe fulfilling these requirements should be as light as possible in order that the delicacy of touch should not be lessened in the exertion to move a heavy mass, and that vibrations that would other-

wise be lost in the probe itself might be communicated to the hand. The probe combining these properties is made of tempered aluminum. The large end will generally pass along the sinuses connected with a wound, and, from its size and shape, it is often possible to tell the nature of the structures with which it comes in contact. It is only exceptionally that the smaller end need be used. (Fig. 9.)

"In probing, to curve the instrument is to complicate it and increase the chances of error in interpreting the position of the exploring extremity.

"When the probe is curved near the exploring end, the other end of the shaft should be bent in the same plane in the opposite direction.

"In case the sinus is tortuous, rather than complicate the exploring instrument, I am in the habit of simplifying the wound. Thus, in following such a sinus, the end of the instrument, after it has passed along one curve, should, if practicable, be brought toward the surface and exposed by careful dissection. The first curve having been eliminated, the re-bent probe can be introduced through the new opening at *b*, the commencement of the second curve, *b c*, and the latter explored. (Fig. 10.)

"In a thirteen years' active hospital service, I cannot recall that I have ever used, in the probing of wounds, the fallacious means of exploration afforded by a flexible mechanical instrument."

As soon as the underlying cause is removed, a sinus generally closes of itself, even though it has previously persisted for months or years.

Improper Drainage of Subcutaneous and Suppurating Tracts.- If, instead of allowing the pus to escape through several small openings, connect them all by an incision so that the entire tract is laid open. Rapid healing by granulation will promptly follow. Revision of drainage, where the suppurating tract lies in the deeper parts may at times be avoided by the use of permanent suction drainage. At other times even this will fail, and operative measures, such as establishment of counter drainage or widening of the existing tract, must then be done.

Sinuses Due to Foreign Bodies. Drainage material, such as gauze or rubber dam, which has escaped notice and slipped into the depth of the wound may account for the persistence of a suppurating tract.

If a foreign body is found lying in the depths of a sinus and it cannot be extracted without enlarging the wound, the tract should be laid wide open, scraped out, and allowed to granulate from the bottom. In wounds which have not been drained but in which suppuration has taken place, healing by secondary intention will progress to a certain point, after which it comes to a standstill until, finally, a *ligature*, *suture*, or a *slough* is thrown off by the tissues and appears on the surface. Prompt closure follows.

Sinuses persisting after incision and drainage of suppurating lymph-nodes either in the neck, axillæ, or groin are, as a rule, due to 1 of 2 causes. Either the skin wound is improperly placed and has been allowed to close too soon, thereby preventing free drainage, or else remnants of broken down lymph-nodes continue to form the source of trouble. If these 2 causes are corrected, the tract granulates and closes without delay (unless syphilis is the cause).

Sinuses after osteomyelitis constitute a large class by themselves. They indicate either the presence of dead bone or local tuberculosis, or both.

After operations for chronic osteomyelitis the patient should be warned that recurrences are the rule rather than the exception and he should be ordered to report as soon as he experiences any pain. As a rule, these secondary attacks are of very low virulence, fistulæ persist for a while, more sequestra separate, and the sinuses close.

Sinuses after Joint Resection. After resection of a joint for tuberculosis, sinuses may remain behind lined with tuberculous granulation tissue; these may or may not lead down to necrosed areas of bone.

In revising a sinus in the neighborhood of a joint, be extremely careful, do not work in the dark, for fear of tearing through the synovial membrane and infecting the joint. The tract should be methodically laid open and followed to its end. Granulations overlying the capsule should be left alone for fear of going too deep with the curet.

Sinuses Due to Tuberculosis. Tuberculous fistulæ are best treated by the Rollier sunlight method (see page 64). The injection of Beck's paste[1] of which so much was expected has not given uniform success. The same may be said of the Bier hyperemic treatment, the iodoform glycerin injection method, and the use of vaccines (tuberculin).

Sinuses Due to Syphilis. Any chronic suppuration which does not prove amenable to the treatment outlined above should awaken the suspicion that perhaps the underlying cause is an undiagnosed syphilis, even in the absence of a positive Wassermann reaction. It will do no harm to try a tentative therapeutic test. With regard to the latter, I know of a number of cases where amputation of the limbs and of the tongue had been performed for sarcoma which subsequently proved to be cases of syphilis. A therapeutic test had been given in all these without effect. Lustgarten, the well known dermatologist, told me of one case of fungus of the knee in which a so-called therapeutic test had failed to cause any change and which was consequently diagnosed as sarcoma. Amputation had been advised, and the patient came to him as a last resort (this was before the days of the Wassermann reaction). Another therapeutic test under his direction was tried, and healing took place within 4 weeks.

This subject is so important that a brief outline of the views of this master of syphilology may be of interest in this connection. His routine was to give deep gluteal injections (upper outer quadrant) of a 2 per cent. bichlorid solution in 2 per cent. salt solution twice a week for a period of 6 or 8 weeks, beginning with a dose of 5 minims and running up to 8 to 10 minims or even higher. He condemned the administration of mercury by mouth or by inunction as unreliable, because one could not tell exactly how much had been absorbed. He did not use insoluble mercury salt for deep injections for the same reasons, and in addition stated that several hundred cases of fatal mercurial poisoning had been published in which patients had suddenly developed the symptoms of intense mercurial poisoning 6 or 8 weeks after all injection treatment had ceased. Apparently a deposit of the so-called insoluble mercurial salt had eroded the wall of a vein and a lethal dose entered the circulation. Lustgarten, therefore, preferred bichlorid of mercury, an absorbable salt, the effect of which can be readily observed within a few days.

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[1] Beck's paste (a mixture of 1/3 bismuth subnitrate and 2/3 vaselin) will temporarily check the amount of secretion escaping from such suppurating tracts. This has been shown to be due to the liberation of small amounts of nitric acid, the bismuth subnitrate breaking down in the presence of living organic tissue and setting free small quantities of the acid. Even in suppurating tracts with no foreign body at their bottom, Beck's paste has proved to be extremely unreliable and disappointing.

For the treatment of actinomycosis, blastomycosis, etc., see Chap. XVI, Vol. I.

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CHAPTER II

POSTOPERATIVE TREATMENT AND POSTOPERATIVE COMPLICATIONS CONSIDERED REGIONALLY

JOHN C. A. GERSTER

THE HEAD

Operations on the Soft Parts. Bear in mind that infection in this region may spread to the meninges. Erysipelas may escape notice through being covered by the hair. Many surgeons prefer to unite scalp wounds by secondary suture if there is the least suspicion of infection. Total scalpings, after healthy granulations have formed, are best treated by Krause full thickness grafts (J. S. Davis).

Operations on the Brain.[1] If there is much shock, while stimulation may be resorted to, it is unwise to lower the head as is customary in shock after operations upon other parts of the body, because of the danger of increasing oozing. The 2-stage principle has done a great deal to diminish the mortality of cranial operations.

Urotropin (hexamethylenamin) is given in large doses as a routine by Cushing and others, with the idea that small amounts of formaldehyd are set free in the cerebrospinal fluid and inhibit bacterial growth.

This idea was based upon the fact that the hexamethylenamin (given by mouth) could be recovered from the cerebrospinal and other body fluids. A number of physiologists have shown that the hexamethylenamin does not break down and liberate formaldehyd except in fluids having acid reaction. Hence in the bile, cerebrospinal fluid, etc., it remains inert. (See also remarks on urotropin under Genito-urinary Tract.)

For the routine treatment of patients who are unconscious or paralyzed, see preceding chapter.

Frequent neurological examinations should be made to ascertain any changes in the status of the nervous system. Ophthalmoscopic examinations and blood-pressure findings will furnish most valuable data regarding changes in intracranial pressure. Lumbar puncture also furnishes data of great diagnostic value.

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[1] See also Vol. II, Chap. XI.

TREATMENT OF THE WOUND.—CLEAN CASES.—Some surgeons remove the skin stitches as early as the second day, in which event it is well to support the suture line with strips of sterile adhesive plaster; others see no advantage in this and wait until the fifth or sixth day.

PURULENT CASES.—Rubber dam or soft rubber tubing is the best material for draining brain abscesses. As the amount of secretion diminishes, the size and length of the drains are decreased. Under no circumstances is any irrigation to be made.

Diet should be concentrated and of a sort not likely to cause fermentation. When there is difficulty in swallowing (bulbar symptoms), the greatest care must be taken to prevent material from entering the air passages. The best way is to feed through a stomach tube.

LATE SEQUELÆ.—HERNIA CEREBRI can be prevented by the wearing of a suitable pad or other retention apparatus. Numerous operations have been devised for the repair of defects in the skull. It was the custom in former days to use plates of gold or celluloid; the present tendency is to transplant bone for this purpose.

EPILEPSY of the Jacksonian type may follow in a few months if the brain becomes adherent to the overlying skull.

The constant pulsation plus firm adhesion at one point is the essential factor in the etiology. Lexer and Rehn, among other German surgeons, recommend the interposition of a flap of fat between the surface of the brain and the overlying tissues. They state that the endothelial cells of the lymph spaces grow out upon the surface of the flap and furnish a serous covering. Experimental work has been done by A. C. Prime which shows that plates of celloidin act as inert material and do not give rise to scar production. Fascial flaps are unsuited for covering defects in the dura because of their tendency to shrinkage and excessive scar formation.

Mastoid Operations.[1]—THROMBUS FORMATION.—Following mastoid operations infection may spread to the lateral sinus. Blood-cultures are of the utmost service in diagnosis. A lateral thrombus may give few symptoms other than those of a bacteriemia. Ligation of the jugular vein to prevent the spread of thrombus formation is discussed in the chapters on Ear (Vol. III, Chap. III) and Postoperative Operations (Vol. II, Chap. III).

MENINGEAL INVOLVEMENT.—Meningeal involvement may be determined by fluid withdrawn at lumbar puncture. (Cytology of the white blood cells and the presence of bacteria in the spreads—it is not necessary to wait for the result of the cultures.)

FACIAL PARALYSIS.—If the nerve has been merely bruised, it will regain its function in due course of time. If it has been divided, anastomosis with the twelfth cranial nerve of the same side into the facial improves matters a great deal, although perfect restitution is never obtained (see Vol. I, Chap. XIII).

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[1] See also Vol. III, Chap. III.

Operations for Trigeminal Neuralgia.—Operations for this affection are discussed in Vol. I, Chap. XIII. Great care must be taken to prevent access of foreign bodies to the anesthetic eye of the operated side. Otherwise particles of matter lodged upon the cornea may cause a great deal of damage before their presence is noted.

Operations on the Face.[1]—In adults there is no need for any gauze dressing after closure of clean wounds of the face; a little dusting powder is all that is necessary. Stitches are removed much earlier than in the rest of the body for the sake of the cosmetic result. When once a wound is dry, it may be covered with flexible collodion (new skin) or some flexible beeswax preparation. Children must be restrained from touching their faces after operation.

In all plastic surgery, especially of the face, it is of the utmost importance to wait a long time between operations, to allow for the full amount of shrinkage of flaps and scars.

THE EYELIDS.—In plastics on the lids it is important that much more material be taken than is actually needed to fill the defect, so as to compensate for the subsequent shrinkage. Be careful that the lashes do not sweep against the cornea and cause ulcers.

THE EYE.—In all inflammatory, non-suppurative conditions about the eye, ice applications and boric acid ointment are sovereign remedies. Wet pads of absorbent cotton or mull are laid upon a cake of ice and are gently wrung out just before being applied to the eye; as soon as they lose their coldness they are exchanged for fresh ones. In suppurative conditions, the application of moist heat in the shape of hourly 15-minute bathings with a saturated boric acid solution will be more effective.

THE NOSE.—Contraction of the artificial nares is prevented by the insertion of drainage tubes wrapped in gauze (see Vol. III, Chap. IV).

THE MOUTH.—Defects of the lower lip are especially annoying because of the continuous flow of saliva.

By waiting a few months a very small oral aperture will gradually dilate to the proper size. The jaws, which at first can scarcely be separated, will finally be opened as widely as is necessary.

HARELIP.—If the suture line parts, wait until granulations have formed or even until the raw surfaces have completely healed before doing anything further.

General Considerations of Operations Upon the Upper and Lower Jaws, Tongue, and Larynx.[2]—Before the coughing and swallowing reflexes return, the head should be kept low and turned to one side; only when these reflexes return should the sitting or upright posture be assumed.

Remember that these patients cannot talk, and that they require constant watchful attendance for the first few days. The more intelligent ones make their wants known by pad and pencil. A bell should always be within reach.

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[1] See also Vol. I, Chap. XII.

[2] See also Vol. III, Chaps. V and VIII.

HEMORRHAGE.—It is unwise to let the patient lie flat upon his back immediately after coming from the operating room. If there be any bleeding, the semiconscious individual simply swallows as the pharynx fills up, and not until a considerable quantity of blood has been lost will attention be drawn to it either by the progressive signs of internal hemorrhage or by the vomiting of a quantity of fresh blood and clots. Hence, oft-repeated swallowing should awake the suspicion of hemorrhage. Instead of disturbing the freshly united tissues by opening the mouth widely and inserting a speculum, simply turning the head and body so that the mouth is depressed will promptly show whether any hemorrhage is present.

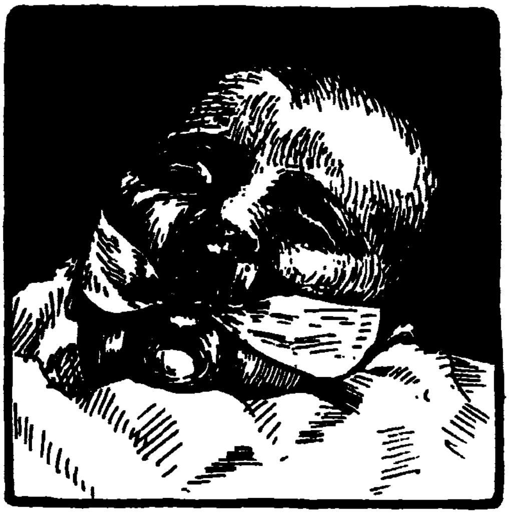

FIG. 1.—ADHESIVE PLASTER DRESSING FOR RELIEVING TENSION OF THE UPPER LIP AFTER HARELIP OPERATIONS. (Hagemann.)

Hemostasis in this region is especially difficult because of the friable nature of the tissues. Because the region is an infected one, secondary hemorrhage is not infrequent. Local ligature, or the hemostatic application of the actual cautery, is indicated rather than ligation of the main vessels through the healthy tissues at a point distant from the seat of trouble; this should be done only as a last resort.

ASPIRATION PNEUMONIA.—Aspiration pneumonia is one of the most fatal complications after operations in this region. Intratracheal anesthesia, however, has become so simplified that there is no excuse for any surgeon's not safeguarding his patients by this means. With the intratracheal tube in place, it is difficult for material to find its way down into the trachea even when the mouth and pharynx are filled with blood or vomitus.

Before the introduction of intratracheal anesthesia, preliminary tracheotomy was frequently done in order to permit firm packing of the back of the oral cavity, thus preventing entrance of blood and oral secretions into the air passages. For the same purpose a tracheal tampon cannula with an inflatable jacket was devised by A. G. Gerster, the inflatable cover being distended after introduction, thus completely occluding the trachea.

Other methods for keeping the air passages clear were to drop the head over the edge of the operating table (Rose's position), and to use Trendelenburg's position. While these positions kept the air passages fairly clear, they increased the oozing.

Removal of oral secretions for the first few days after operation by permanent or interrupted suction is of great value in preventing aspiration pneumonia and affords much comfort to the patient.

CARE OF THE MOUTH. Irrigations of permanganate of potassium (1 : 5,000), applied with considerable force to the crevices between the teeth, are excellent for adults. For children, a hyposulphite of soda (a dram to the ounce) solution has the advantage that if some of it is swallowed, no harm results.

Infections of a resistant character (pyorrhea alveolaris) or those which show a tendency to spread (incipient noma) require cureting away of the diseased tissue followed by cauterization with saturated solution of trichloracetic acid (use a 2 per cent. to 4 per cent. solution of novocain for dissolving the crystals); the cauterization is repeated on the second and the fourth days. In applying the acid, care must be taken to protect adjacent tissues by packing away the tongue and cheeks with dentists' wadding, greasing the lips, and, above all, using just enough solution to accomplish the purpose in hand.

Irrigations of ½ per cent. formalin (1 : 80 of the commercial 40 per cent. "formalin"), every 4 hours during the waking hours, supplement the action of the trichloracetic acid. The lips and face should be coated with grease (cocoa butter) beforehand. As soon as matters improve, in a day or so, the formalin solution is discarded for the weaker irrigating solutions mentioned above.

A quiescent pulmonary tuberculosis sometimes changes to a florid phthisis after an operation in the oral region.

FEEDING. Feeding may be accomplished by means of a soft rubber stomach tube of moderate caliber passed through the nose and left permanently in place. This is particularly suitable after operations on the mouth and is often less disturbing than passing the tube through the mouth each time the patient is to be fed.

For the sake of keeping the parts as quiet as possible, rectal feeding is often resorted to for the first 5 to 7 days after operation. In certain cases of neoplasm of the tongue or larynx, in which there is marked emaciation, a preliminary gastrostomy is made; through this the subjects are fed not only before operation, but afterward until the operative wounds have healed.

RECTAL FEEDING.—It is very doubtful whether anything except fluid and very diffusible substances are absorbed by the mucous membrane of the large intestine. The most recent views reject the use of albuminous materials in rectal feeding. However, in deference to the rather fixed notions prevalent, I give the usual recipe for a nutrient enema:

℞ Peptonized milk 4 oz.
Egg 1.
Medication if desired.

Give very slowly; keep patient quiet afterward; the bowel should be cleansed with a colon irrigation at least once every 24 hours.

Recently much has been written in favor of dextrose solutions in distilled water subcutaneously as a means of keeping up the patient's nutrition. This has also been tried with success per rectum. Yet it must be remarked that in certain cases the sugar solutions have undergone fermentation and have given rise to flatulence.

Rectal feeding at best is a temporary expedient. The rectum rarely remains tolerant longer than a week.

Operations on the Nose.[1]—HEMOSTASIS. The time honored custom is to pass a Belloque's sound or a catheter through the nares until its point can be seen and seized in the pharynx just behind the soft palate when it is brought well into the mouth; a stout piece of silk is then tied to it and it is withdrawn from the nose; to the oral part of the silk a wad of cotton or gauze is firmly tied. This wad is then introduced into the pharynx; by pulling upon the nasal end of the string, the posterior nares are effectually blocked. The anterior nares are then packed. (This tamponade must not be left in place longer than a few hours because of the risk of infection.)

PREVENTION OF DEFORMITY. Deformity is especially to be guarded against in the presence of fractures (the broken nasal bones unite with astonishing rapidity) and after operations upon the septum. Celluloid drains are extremely useful in this region.

PREVENTION OF INFECTION. —Do not pack the nose, because this may lead to retention and to the spread of infection to the ear (by way of the eustachian tube) or even the meninges. In any severe infection of the nose, it is well to inspect the ear drums frequently to make sure that the trouble has not spread to this region.

Neglect to observe asepsis has repeatedly led to intranasal erysipelas, a very fatal form of this disease. I know of several cases of fatal erysipelas of intranasal origin following the use of a dirty eustachian catheter.

Operations on the Antrum and Frontal Sinus.—The suction apparatus of Henry Horn, of San Francisco, is extremely useful in draining these accessory air spaces (Fig. 2). After prolonged irrigation with normal saline (to loosen dried secretions) the suction tip is applied to one nostril firmly enough to make an air-tight joint; the patient closes the other nostril by lateral pressure with the finger. He then says "eeh" (to close the posterior nares), and at this moment the suction is applied (never more than 12 mm. Hg. negative pressure; more than this causes a violent headache). It is remarkable to see the amount of material obtained in this manner.

Exuberant granulations in any of the accessory air passages are apt to be mistaken for neoplasms; they block the outlets and cause retention, which in turn gives rise to fever and malaise.

Normal saline solution is the best for loosening up *inspissated secretions.* Permanganate of potash or potassium chlorate solutions are also frequently used.

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[1] See also Vol. III, Chap. IV.

Persistent suppuration in the antrum of Highmore is often due to penetration of the antral floor by unerupted teeth. The trouble subsides as soon as the teeth are attended to.

Cleft-palate Operations.[1] Hemorrhage usually is controlled by local pressure applied for a few minutes or by a fine hemostatic suture. The recently discovered thrombokinase applied directly to the mouth of the bleeding vessel is extremely effective.

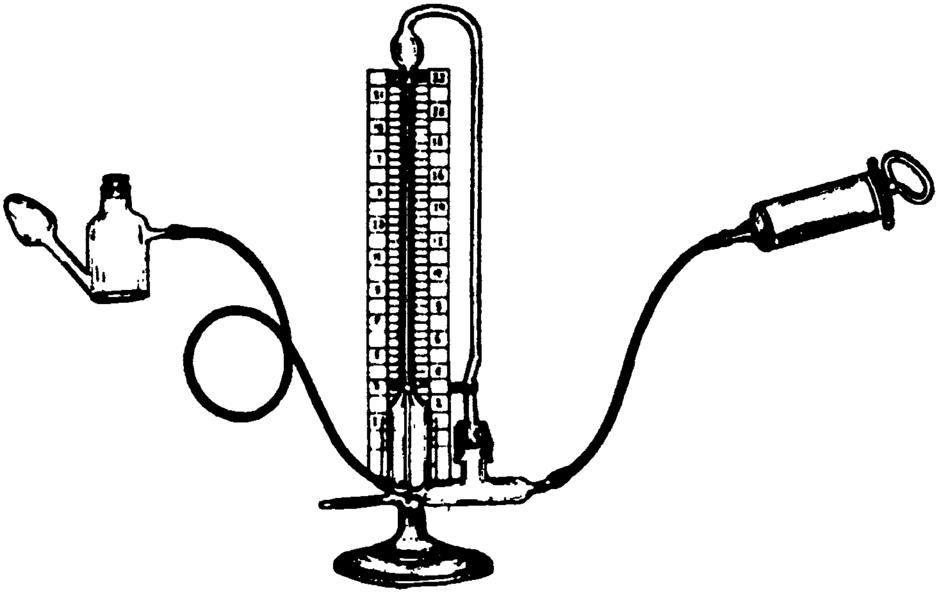

FIG. 2.—HORN'S SUCTION APPARATUS FOR DRAINING THE ACCESSORY AIR PASSAGES.

If the stitches are cutting through, remove them; they have ceased to be of use.

To guard against infection and shock, it is better not to attempt too much at a time. Ever since the days of Langenbeck it has been advised to do the harelip and cleft-palate operations separately. Goyder (5) says that repair of a harelip in a few months leads to material narrowing of the cleft in a complete cleft-palate, especially in front. If the immediate result is not perfect, at first do nothing; small gaps in the suture line usually close spontaneously; if they should persist, they can be closed by a small supplementary plastic.

SPEECH TRAINING. Speech training after cleft-palate operations is an extremely difficult and thankless task. Often, in spite of every effort on the part of patient and physician, the tone of the voice remains the same and phonation is unsatisfactory. It has been said that the operation of Schönborn (see Postoperative Operations, Vol. II, Chap. III), by which the short velum palati is lengthened by the addition of a flap from the posterior pharyngeal wall, has been of benefit in certain cases. Several months are allowed to pass before the flap is cut loose from the pharyngeal wall; meanwhile the nose must be irrigated.

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[1] See also Vol. I, Chap. XII.

The easiest part about cleft-palate operations is the actual operation. It is not surprising that even after a perfect cosmetic result the voice and speech do not improve in spite of the most careful training when one considers the deficient nervous and muscular supply of the parts.

Operations on the Jaws.—TOOTH EXTRACTION.—Tooth extraction may become necessary because of root inflammation arising after operation upon some other region of the body, just as mastoid trouble may occur incidentally. It is important not to delay action with this, once the diagnosis is definitely made; osteomyelitis of the superior maxilla is an extremely grave condition having a very high mortality, especially in children.

Tooth extraction may be followed by annoying and persistent hemorrhage especially in hemophiliacs. If packing, the actual cautery or hemostatic suture does not succeed, and there is no laboratory near by to furnish fresh extract of lung (thrombokinase) for local application, before resorting to transfusion the subcutaneous injection of defibrinated blood at some convenient spot such as the thigh or the abdominal wall may be tried.

FRACTURE.—In certain of the operations for carcinoma of the floor of the mouth or the tongue, the lower jaw is divided to give better access to the field of operation. If the section be made oblique, and from behind and above, downward and forward, the posterior fragment (to which the masseter is attached and which is, therefore, drawn upward) will project beneath the anterior fragment and tend to support it. If the section of the jaw is made in a vertical direction, it is almost impossible to prevent upward displacement of the posterior fragment.

A good interdental splint fitted by a dentist is the ideal treatment for fracture of the lower jaw, provided the subject has teeth. In the absence of teeth, the problem is much more difficult. Numerous makeshifts have been devised, none of which are entirely satisfactory. If it is possible to have the mucous membrane heal so that the fracture lies in an aseptic field, bone grafting, plating, and similar measures may be brought into play.

DISLOCATIONS OF THE LOWER JAW are very prone to recur. Hence some light bandage or retention apparatus to keep the jaws from separating widely should be worn for a while after reduction.

RESECTIONS OF THE SUPERIOR MAXILLA require the wearing of an obturator. Only after healing has been completed can fittings for this be begun. When the orbital plate is removed at operation, it naturally causes the eyeball to drop downward. Subsequent bone grafting furnishes a better support than an obturator.

RESECTIONS OF THE INFERIOR MAXILLA.—After resections of the inferior maxilla or tongue, there is a tendency for the tissues to drop backward and cause choking. Turning the patient into a prone or even a partly prone position may be of the greatest help.

Operations on the Tongue.[1]—For the general principles of postoperative treatment in this region see General Considerations on page 73.

DRAINAGE.—Von Bergman established permanent drainage after resections of the tongue by suturing the mucous membrane to the skin at the posterior angle of the cutaneous wound, thus furnishing drainage through an oblique fistula. When the patient drank, leakage was prevented by simply pressing a piece of gauze against the skin just above the external opening of the fistula. At the end of a fortnight, the opening could be closed by a few stitches after freshening the edges.

HEMORRHAGE has been mentioned on page 74.

INFECTION. Infection may give rise to obstruction to the breathing. The removal of a few stitches may suffice to release a quantity of pus; on the other hand, if the swelling is due to diffuse inflammatory infiltration, in addition to making multiple incisions, it may be necessary to intubate with an O'Dwyer tube or even a simple woven catheter (as in intratracheal insufflation), or, as a last resort, to perform tracheotomy.

SPEECH is regained to a remarkable degree even after total removal of the tongue.

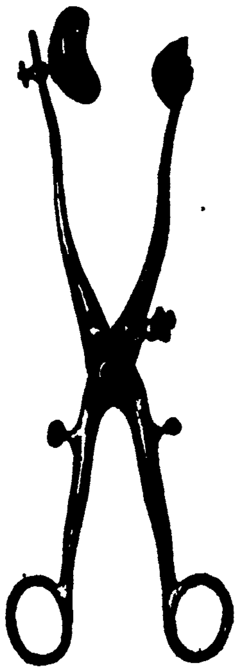

FIG. 3. TONSIL HEMOSTAT.

Operations on the Tonsils.[2] Tonsillectomy is occasionally followed by troublesome hemorrhage, which may be controlled by manual compression for 10 minutes or the application of a tonsil hemostat. This instrument has 2 long arms, 1 of which lies in the oral cavity, the other on the outside of the neck; the ends are guarded by pads. The inner one is applied to the bleeding point, and the instrument is then closed sufficiently to bring gentle compression to bear (Fig. 3). Ligation in this region is very difficult. The actual cautery, on the other hand, has proven of the greatest value.

Cases of carcinoma of the tonsil require practically the same after-treatment as those of the tongue.

Retropharyngeal abscess should be drained through an external opening in the neck rather than through the pharynx; with the former, there is less likelihood of flooding the trachea, or later of retention. External drainage is not without its own dangers; secondary hemorrhage has followed long contact of a drainage tube with the jugular vein or carotid artery. Rubber tissue is softer and less apt to cause erosion of the vessel wall.

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[1] See also Vol. III, Chap. V.

[2] See also Vol. III, Chap. VI.

THE NECK[1]

General Considerations.—BANDAGE.—In any large wound of the neck (any wound where adhesive plaster will not do to hold the dressing in place), the dressing must fill the space from the lower jaw to the sternum if one is to make sure against shifting. A narrow circular bandage high up will drop down and a similar one low down will move upward. Both tend to move toward a point at the center.

A mass of ruffled gauze, covered with a gauze compress next to the wound, is held in place by several gauze rollers and a bandage. The rollers and bandage should have their first turns placed at the middle of the neck, the succeeding turns going above and below, and the final turns again returning to the center. A large sheet of rubber tissue may be placed partly covering the gauze and partly covering the face, just before the bandage is started; when the bandage has once covered the gauze, that part of the rubber tissue still exposed is turned down over the dressing and the succeeding turns of the bandage cover it. This prevents soiling of the deeper dressings with vomitus.

The collar type of dressing is insufficient in extensive wounds reaching high (suboccipital and high cervical exposure of the spinal cord) or reaching low (large goiter). In such cases the bandage must take in the head and sometimes even the axilla (Fig. 4).

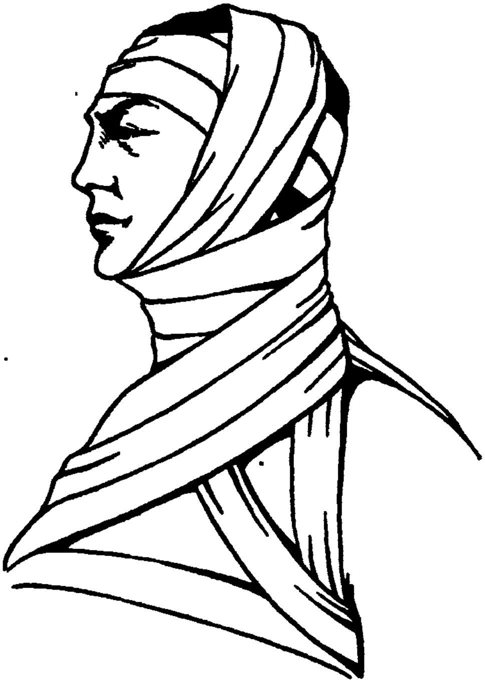

FIG. 4.—BANDAGE FOR EXTENSIVE WOUNDS OF THE NECK.

RESPIRATORY COMPLICATIONS.—Respiratory complications due to dysphagia and stagnation of the oral secretions are prone to follow operations upon the neck (even after the employment of intratracheal insufflation).

Permanent or interrupted suction is of great convenience in keeping the field clear of mucus and blood; at the same time it prevents oral secretions from reaching the air passages. After operation it serves the same purpose for the first few days, until swallowing is attended with less pain.

INJURIES TO THE JUGULAR VEIN.—Ligation of the vein at the time of operation is not apt to be followed by serious consequences (circulatory disturbances of the brain).

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[1] See also Vol. III, Chap. VII.

INJURIES TO THE CAROTID ARTERY.—Ligature of this structure with a previously unimpaired circulation, on the other hand, is frequently followed by speedy death from insufficient blood supply to the brain. If a gradually developing obstruction to the blood current has afforded time for the development of a good collateral circulation, ligature of the common carotid will not impair cerebral circulation.

Secondary hemorrhage may follow drainage of deep seated abscesses of the neck in which the drainage tube has been lying in contact with the great vessels. As a rule, a fatal exsanguination takes place in a few moments.

INJURIES TO THE THORACIC DUCT.—Injuries usually follow extensive dissection at the root of the neck. The steady leak of chyle leads to speedy inanition. It may be impossible to isolate and ligate the injured duct. Under such circumstances the wound is firmly packed with a gauze tampon and the skin sutured over it; the wound is reopened after several days, usually no leakage follows removal of the gauze. (I have sutured the duct successfully in 3 cases. EDITOR.)

Because of the numerous anastomoses present, ligation of the thoracic duct does not cause disturbances of lymph circulation or nutrition.

INJURIES TO THE NERVES.[1] Division of the vagus on one side is not a serious matter. If the injury is discovered at the time, the divided ends should be sutured with fine catgut.

Until routine postoperative laryngological examination of goiter patients was made, it was not realized how often paralysis of the recurrent laryngeal followed thyroidectomy. In most instances this passes off in time.

The phrenic is rarely injured at operation. Of late years it has been purposely divided to put the respective half of the diaphragm at rest. In a case of tuberculous empyema with multiple sinuses, instantaneous cessation of reflex shoulder pain has followed division of the phrenic under local anesthesia.

SCARS.—Scars of the neck have a great tendency to spread. To a large extent this may be prevented by careful union of the platysma before uniting the skin. Vertical scars are much more unsightly than horizontal ones. If the latter are located exactly in the bottom of natural folds of the neck, they may scarcely be visible. In some of Kocher's thyroidectomy cases, it is impossible to recognize the scar except by close examination under a strong light. With a little patience and care, it is often possible to accomplish one's object through several horizontal incisions instead of resorting to 1 long vertical opening.

CONTRACTURES.—Contractures of the neck following extensive suppuration often prove amenable to orthopedic measures if treated early. If, however, they are brought to the surgeon late, it may be necessary to excise the entire scar and resort to some plastic operation to cover the defect. Transplantation of fat is the best way to fill up unsightly hollows and to prevent adhesion of the skin to the deeper lying structures.

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[1] See also Vol. I, Chap. XIII.

Operation for Tuberculosis of the Cervical Lymph-nodes.—Recurrence of tuberculous lymph-nodes after partial extirpation is better treated by the sunlight treatment so successfully developed by Rollier than by a second operation. In fact, this is the method of choice in almost all cases of this affection whether with or without fistula.

Thyroidectomy.[1]—A subcutaneous drain is led out through a stab wound in the episternal notch, the original collar incision being completely closed. The drain is removed at the end of 48 hours, when, if the heart's action is satisfactory, the patient may get up. In severe exophthalmic cases this may not be advisable, but in the cases of simple goiter it is the rule.[2]

Cachexia strumipriva and tetany are almost never seen nowadays. It is easy enough to supply thyroid deficiency by feeding thyroid extract, but deficiency of the parathyroids is much more difficult to treat. Transplantation has been made with but temporary success.

Tracheotomy.[3]—RESTRAINT.—The semiconscious patient should be prevented from touching the tube or its tapes. Guard against this before it has happened, not afterwards.

CARE OF THE TUBE.—The surgeon should make sure that the nurse is perfectly familiar with the mechanism of the tracheotomy tube. She should remove the inner tube, clean and replace it in his presence. A feather is used to keep the inner tube clear of mucus; when, in spite of this, too much secretion accumulates, the inner tube is removed, cleared of mucus, boiled and replaced.

A wet pad of gauze or a suitably trimmed piece of sponge is kept covering the aperture of the tracheotomy tube to act as an air filter for the first few days, until the tissues of the air passages become accustomed to the new condition. This sponge or pad dries out very rapidly and must be remoistened at least every 15 minutes. If the nurse leaves the patient for a moment, the latter must have a bell or some other means for summoning aid. The tapes holding the wet pad or sponge must never be confused with those holding the tube in place. It is better to have the knot of the tube tapes as far behind as possible and the knot of the pad tapes well up in front to one side.

Dyspnea may indicate accumulation of dried secretions at the internal, lower end of the inner tube, or in the air passages themselves, or partial or total displacement of the tube. Displacement of the tube is a most serious accident, which may terminate fatally long before the surgeon can reach the patient. In low tracheotomy the accident may follow a violent fit of coughing. Replacement must be carried out by retracting the soft parts with one pair of retractors and the wound in the trachea with another pair, the latter being small twopronged "sharps." Attempts at replacement in any other manner simply waste precious time. The various steps of exposure and insertion must be made under the guidance of the eye.

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[1] See also Vol. III, Chap. VII.

[2] Cardiac decompensation in acute exophthalmic goiter is managed according to the principles of internal medicine.

[3] See also Vol. III, Chap. VIII.

Secondary hemorrhage and diphtheritic infection require no special mention here.

In every case of tracheotomy it is well to have the following list of articles in readiness for instant use: another tracheotomy tube of the same size as the one inserted; 2 pairs of retractors (1 large (for retracting the soft parts), the other small (to hold the wound in the trachea open while the tube is being slipped in); some sponges and the outfit necessary for applying a ligature or a hemostatic suture; finally a tankful of oxygen.

By the end of a week or 10 days the tube will lie in a well-defined rigid passage, which does not collapse upon its withdrawal. Hence removal at this late time is not usually attended with the grave risks present at first.

DECUBITUS OF THE TRACHEAL WALL. The appearance of blood-tinged sputum, a few days after the insertion of a tracheotomy tube, is very suggestive of the existence of an ulcer from pressure of the tube. This slight and significant hemorrhage may be shortly followed by a severe secondary hemorrhage. In any case it is important to make an immediate change. Either the tube should be entirely removed or, if the laryngeal obstruction be still present, a smaller or a longer tube of different shape should be inserted, the object being cessation of pressure on the ulcer's surface. In case of persistent secondary hemorrhage, make sure, before reopening the wound, that the blood does not come from some superficially located spot.

All this emphasizes the importance of dispensing with the tracheotomy tube at the earliest possible moment. Under antitoxin, the laryngeal membrane disappears rapidly; it is often possible to remove the tube on the third day. Intubation has done away with tracheotomy to a very large extent. However, even now at times, in spite of the antitoxin treatment and the O'Dwyer intubation, tracheotomy will occasionally be unavoidable.

In other cases dyspnea immediately follows the withdrawal of the tube. According to Reichel this is not always the result of actual organic stenosis; it may either be due to inflammatory infiltration of the vocal cords or else the child has, so to speak, gotten out of the habit of using its vocal cords. Now a tube with an opening on its convexity should be introduced. After it is in position, if the outer end be closed, the air from the lungs after entering the lower opening passes out through the lateral opening up to the glottis and so out. The outer end is closed with a fenestrated plug. As the patient becomes accustomed to having part of his air supply travel by the natural route, the fenestrum in the plug is gradually closed until finally all air passes by the proper passage. Should dyspnea come on, the outer end of the tube is simply opened again. Repeated attempts should be made to accustom the patient to breathing through the proper channels. As soon as this has been accomplished, the cannula is withdrawn.

Exuberant granulations which often spring up in the bed of an intratracheal ulcer due to pressure necrosis of a tracheotomy tube (the same is true of intubation of the larynx) may obstruct sufficiently to cause dyspnea. While there may be no signs of obstruction at the time the cannula is removed, these may come on later when the granulations have had time to grow.

To determine the site of obstruction (whether above or below the tracheotomy wound) Trendelenburg has suggested the introduction of a fenestrated cannula; if dyspnea is caused by stopping up the outer end of the cannula, the obstruction lies above; if no dyspnea occurs, one may assume that the tube, upon being introduced, has slipped past the obstructing swelling and is holding it aside. Reichel says that unfortunately this rule applies only to a few cases.

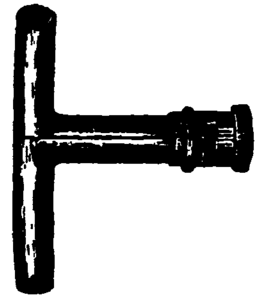
Fig. 5.—Two-piece Cannula Used in Treatment of Tracheal Stenosis. (Dupuis.)

Treatment of intratracheal granulations is most unsatisfactory; either they must be kept flat by wearing a special cannula made in 2 pieces, which maintains the intratracheal lumen, or else the tracheal wound must be reopened, and the granulations burnt down with the actual cautery. Intratracheal insufflation of the trachea below, while this is being done, will prevent aspiration of blood or mucus.

The Dupuis cannula (Fig. 5) is a tube with a stem projecting at right angles from its side half way from either end. The tube is divided transversely at its middle, and the dividing line also bisects longitudinally the holding stem, so that each half of the tube has a corresponding half of the holding stem attached to it. The tube is inserted, one half at a time, into the trachea, the 2 halves of the stem projecting out of the tracheotomy wound. They are threaded so that a nut slipped on binds them together and holds the halves of the tube true.

It is rarely necessary to make a second tracheotomy lower down to afford the operator a free hand in treating postoperative stenoses.

Granulations are very prone to recur. When they have died down, one has to reckon with cicatricial contraction.

Prevention, by the choice of a cannula which is not too large, and in the removal of the tracheotomy tube at the earliest possible moment, is of far more importance than any of the innumerable mechanical makeshifts for treating the untoward after-effects of a poorly or unfortunately managed case.

REACTIONARY SWELLING following tracheotomy for the removal of a foreign body may render it necessary to retain the tube in place for a day or 2.

Operations on the Larynx.[1]—The degree of reactionary swelling after endolaryngeal operations is extremely variable; in the severest cases so much obstruction may develop that tracheotomy becomes imperative.

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[1] See also Vol. III, Chap. VIII.

EDEMA OF THE GLOTTIS.—Edema of the glottis may follow any inflammatory process in the neighborhood of the larynx. In the presence of this trouble avoid procrastination. First of all seek to open the abscess, using a large enough incision to see the structures clearly. Opening such an abscess often causes the perilaryngeal swelling to subside. If it does not, the breathing becomes more and more embarrassed and the laryngeal mirror or the tip of the inserted index finger reveals extreme swelling of the arytenoids. Do not bother with scarification of the larynx which is of little avail, but do a tracheotomy without delay (Reichel). This should be heeded especially if the surgeon is practicing in the country and the patient's attendants cannot summon competent help at short notice.

In emergencies, where the danger of suffocation is imminent, temporary intubation of the larynx with a catheter (preferably a woven one, No. 22-24 French) will tide matters over until an O'Dwyer tube can be inserted, or tracheotomy can be performed.

HOARSENESS. One cannot predict whether hoarseness, which invariably follows tracheotomy, will entirely disappear.

MEDIAN LARYNGOTOMY. Bleeding from a small arterial branch may require re-opening of the larynx and the application of a ligature (which is extremely difficult), a hemostatic suture, the actual cautery (the method of choice), or even direct compression. The use of thrombokinase, if this extract can be obtained, is the ideal method.

In the secondary closure of a median laryngotomy, one must exercise the greatest care to avoid inaccurate coaptation. Laryngeal stenosis is prevented by repeated passage of bougies or eventually division of the stricture (see Vol. III, Chap. VIII).

LARYNGECTOMY.—If the operation is done in 1 stage, there is danger from infection of the deep planes of the neck and fatal mediastinitis. To prevent this, Crile and others expose and pack off the larynx a week or 10 days before its actual removal; by the end of that time, granulations have walled off the operative field. To prevent leakage of oral secretions into the defect left by the removal of the larynx, Bardenheuer has closed off the region of the upper larynx from the mouth by a suitable plastic of the mucous membrane of the arytenoids or, if these were gone, of other adjacent material.

The advantages of preliminary gastrostomy and rectal feeding have been referred to above. At the end of a week or 10 days feeding by stomach tube may begin. Attempts to swallow should be made very early.

Operations on the Esophagus (Cervical Part).—INFECTION.—The dangers from infection after operations upon the esophagus are as great as after laryngectomy (see above).

SECONDARY HEMORRHAGE.—Erosion of vessels from pressure by a drainage tube is the commonest cause of secondary hemorrhage in this region. It rarely comes from the carotid artery or the jugular vein, in which case a speedy and fatal exsanguination usually follows; so frequently does the bleeding come from the inferior thyroid that Fischer (after Reichel) advises prompt ligation of the inferior thyroid artery whenever a secondary hemorrhage is encountered. Whether bleeding comes from the mouth or from the external wound, there should be no delay in reopening the latter, and locating and checking the hemorrhage.

It is safer to rely for several days upon rectal feeding than to risk injury of the suture line by passage of the stomach tube.

DIVERTICULA.—Operated upon with adequate asepsis, diverticula of the esophagus in the neck should heal by first intention.

CICATRICIAL STENOSIS should be guarded against by the passage of esophageal bougies after healing while the scar is still soft. (See Vol. III, Chap. X.)

THE THORAX

Operations on the Breast.[1]—AMPUTATION.—If the plastic closure method of Jabez Jackson is used (or any other method affording the same end result), the arm can be maintained at right angles to the body and the dressings can be applied with the limb in this position. It is important to use plenty of gauze to give elasticity to the dressing. It should be firm enough to afford moderate compression to control oozing, and yet not tight enough to interfere with respiration. The accompanying illustrations (Fig. 6, A, B and C) give a method of holding a breast or axillary dressing in place which constricts less than the customary spica. The bandage returns the way it came after passing around the arm. Each loop is passed from the opposite side and holds the preceding one in place.

As soon as the patients have recovered from the after-effects of anesthesia they should be encouraged to get up. Movements of the arm should be begun from the second day on. The drainage tube should be removed on the second day after operation without disturbing the rest of the dressings. If all goes well, the first change of dressing need not take place until the end of a week or 10 days.

Lymphatic stasis of the arm after breast amputations should be treated by frequent massage and diathermy. If this is not successful, one of several operations for re-establishing the channels for lymphatic return should be tried (see Vol. III, Chap. XIII). Sometimes local recurrence of carcinoma takes the "cancer en cuirasse" form which, to casual examination, may simulate a lymphatic stasis.

Infection after breast operations should be no more frequent than after "clean" laparotomies. If it is, probably the trouble has its origin in failure to sterilize a sufficiently large skin area or in careless draping whereby uncleansed skin becomes inadvertently exposed during operation.

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[1] See also Vol. III, Chap. XIII.

BREAST ABSCESSES.—Suppuration may persist long after drainage of the breast has been established; this generally means that, inasmuch as the process is frequently a diffuse one, the original opening has missed several foci of suppuration. The **Bier treatment** (small incisions and repeated aspiration) is eminently suited for curing this condition. A cup, large enough to accommodate the entire breast, should have its margin greased to insure an air-tight joint, suction is applied, sufficient to withdraw pus from the abscess and milk from the nipple, **but there should be no pain.** The treatment is applied once or twice a day for from 10 to 30 minutes.

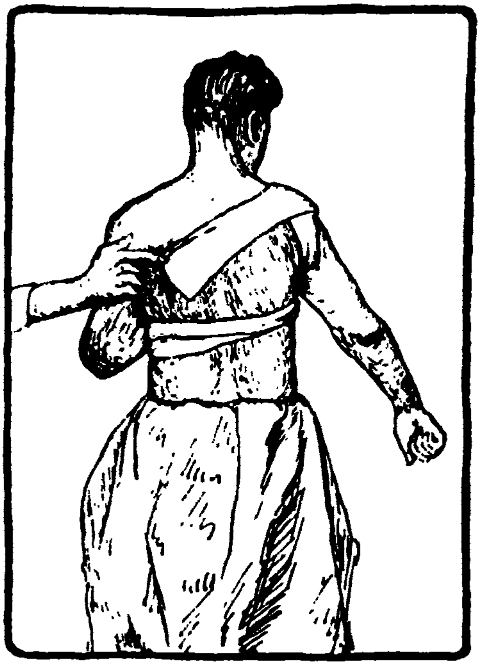

FIG. 6A.—BANDAGE FOR AXILLA AND SHOULDER. The first two turns have been applied, bandaging completed.

Contracture of the arm in adduction to the body after amputation of the breast or after drainage of subpectoral abscesses should be prevented by instituting active and passive motion early, as well as by fixing the arm in adduction at the first dressing. The "Z" plastic—an excellent method of curing this—is described elsewhere (Vol. III, Chap. XIII).

SUBPECTORAL ABSCESSES.—To prevent the formation of contracture the arm should be put up in abduction for a few days.

Operations on the Pleura.—PLEURAL EFFUSIONS.—TECHNIC OF ASPIRATION.—The sharper the needle for aspirating pleural effusions, the less pain to the patient. The needle should avoid the lower margin of the rib for fear of injuring the nerves and vessels in this location. Before puncture, the tissues should be drawn taut to one side, so that, after withdrawal of the needle, the holes it has made through the different planes will not lie in the same line; thus leakage is avoided. All things being equal, the usual site for puncture is in the ninth interspace in the posterior axillary line.

If a Potain aspirator is to be employed, it is well to test its capacity for suction by inserting the needle into a vessel containing some sterile water (under the usual aseptic precautions).

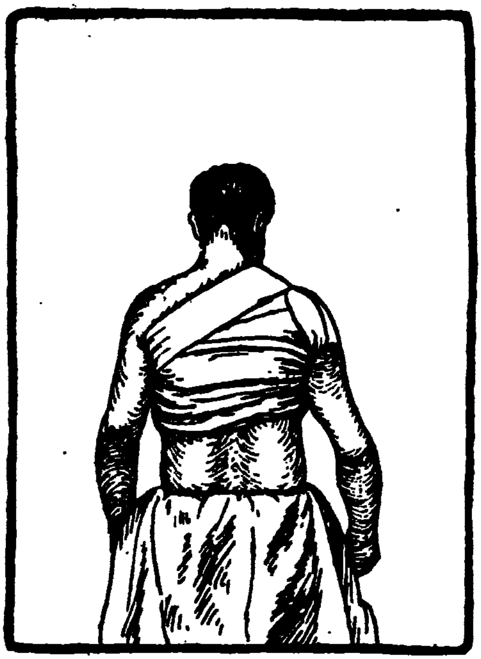

Fig. 6B.—Bandage for Axilla and Shoulder. Rear view.

I once saw a patient nearly killed by an inexperienced internist who had filled the reservoir with air under pressure instead of creating a partial vacuum. Upon turning the cock, after insertion of the needle, the air under considerable pressure rushed in, still further displacing the mediastinal organs to the opposite side. As just said, the patient barely escaped with her life.

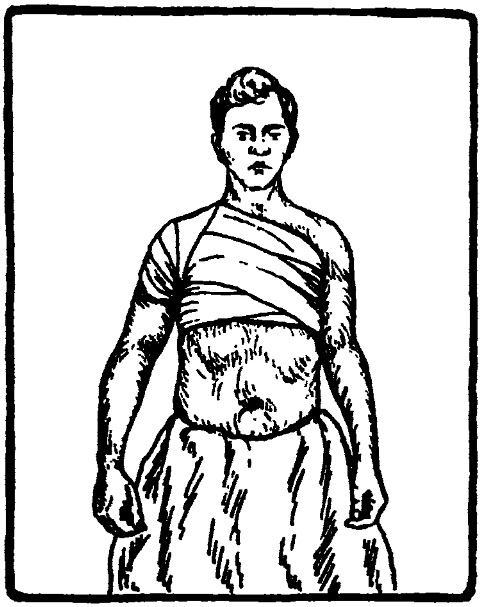

Fig. 6C.—Bandage for Axilla and Shoulder. Front view.

The fluid should be withdrawn slowly. Suction must instantly cease upon the slightest subjective distress. This often necessitates leaving behind considerable amounts of fluid; the oxygen replacement method, described below, circumvents this difficulty.

After withdrawal of the needle, a small piece of sterile gauze, the size of a postage stamp, is applied to the punctured wound and is held in place by 2 or 3 narrow strips of adhesive plaster.

Oxygen Replacement.—In the aspiration of pleural effusions, Schmidt

(10) and Davies (2) both advise oxygen replacement of the exudate whenever there is the slightest distress during a paracentesis. Two needles are used—1 is inserted low down to carry off the fluid, the other, inserted a few spaces higher up, permits the ingress of gas replacing the fluid. For a long time it has been observed that aspiration of exudates, especially of those upon the left side, may cause the gravest collapse. The theory is that the fluid has gradually pushed the heart over to the opposite side and that the withdrawal of exudate within the space of a few minutes displaces the heart too quickly. The replacement of fluid by an absorbable gas does not displace the heart (and mediastinum) at the time of aspiration. The gradual absorption of the gas permits a slow return to the normal, extending over several days. If it is desired to make this return still slower, nitrogen may be used instead of oxygen, the former being much more slowly absorbed than the latter.

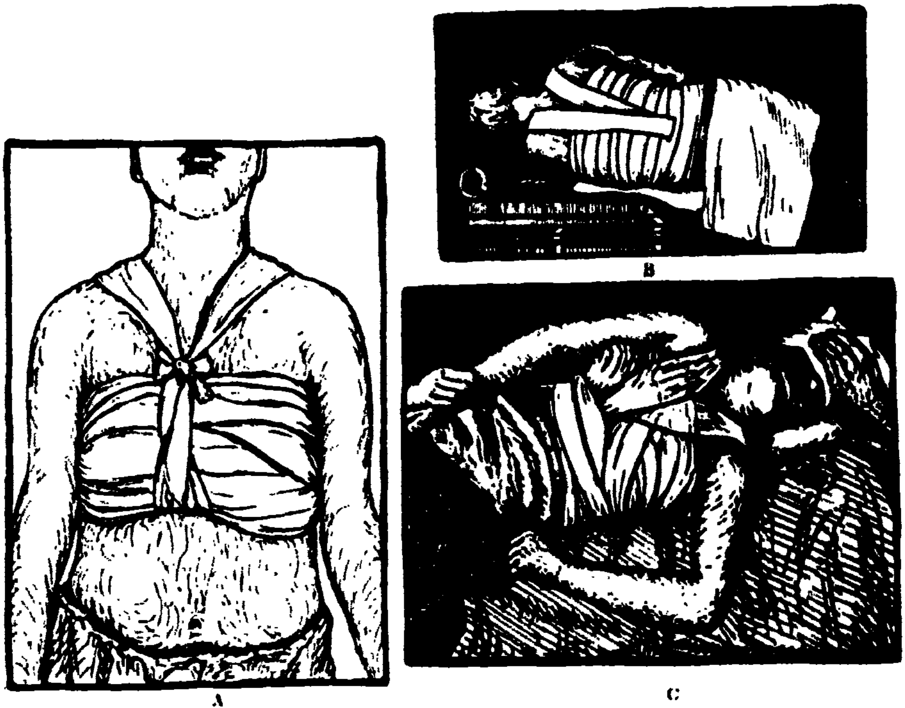

Fig. 7.—Bandage for Empyema with Shoulder Straps. A, Front. B, Back. C, Another way of accomplishing the same purpose.

Drainage by Free Incision.—Before the days of artificial pneumothorax it was observed that drainage by free incision was less likely to cause collapse than aspiration. The air entering the chest replaced the escaping fluid and thus prevented mediastinal displacement.

THORACOTOMY FOR EMPYEMA.[1]—The 3 standard types of drainage are as follows:

(1) The Usual Rubber Drainage Tube, the Mouth of which is Covered by a Thick Layer of Gauze.

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[1] See also Vol. III, Chap. XI.

A word of caution is necessary in regard to the drainage tube. Nowhere in the body is a drain so apt to escape unnoticed into the depths of the wound. Transfixion in a single direction is often not sufficient. As a rule, it is safer to have the tubes' outer ends transfixed by safety-pins lying at right angles to each other. The skin should be protected by a split compress.

The voluminous gauze dressing is held in place by a circular bandage; the latter must not be too tight, otherwise breathing is shallow and labored. If, however, the bandage is loose enough to permit unhindered respiration, it drops down and carries the drains out of the wound. For this reason many men hold the outer ends of the tubes in place by adhesive straps. The simplest way of preventing displacement of the dressings is to make shoulder straps of bandage material; these effectually prevent slipping (Fig. 7, A, B and C).

(2) VALVULAR DRAINAGE.—There are a host of variations of this method, some dating back to pre-antiseptic times. One of the simplest forms was reported by F. B. Lund, of Boston. A flap of skin overlies the mouth of the drainage tube. The tube is sutured into position to prevent its falling back into the pleural cavity. The skin flap permits the escape of pus but prevents the ingress of air. All forms of valvular drainage must be carefully watched; they tend to become clogged with fibrin or dried pus (see also Vol. III, Chap. XI).

(3) CONSTANT SUCTION must not be too great, otherwise the tissues will be tightly sucked against the mouth of the tube and will block it; furthermore, the adjacent pleural surfaces are apt to adhere to one another. Retention is sure to follow.

Under no circumstances is the pleural cavity or a lung abscess to be irrigated.

UNILATERAL PNEUMOTHORAX.—At first change of dressings after drainage for empyema, sudden severe dyspnea may follow. The explanation of this is that, upon removal of the dressings occluding the opening in the pleura, with consequent admission of air and establishment of atmospheric pressure against the side of the mediastinum, this structure is drawn over to the intact side by its normal negative pressure. During inspiration it is drawn over still more; during expiration it only returns a little. Hence the intact lung cannot expand enough to draw in a sufficient quantity of air.

In those people whose mediastina are either more inherently resistant to lateral displacement, or where chronic infiltration has stiffened normally movable mediastinal structures, or, as is most frequently the case, where the lung is adherent either to the diaphragm or chest wall, the entrance of air into the pleural cavity is not followed by dyspnea.

Anything which prevents this drawing over of the mediastinum with each inspiration will relieve the dyspnea. Thus, on the operating table, simply grasping the lung and holding it still will steady the mediastinum and the dyspnea will be instantly relieved. Under the usual conditions of after-treatment the lung is either covered with granulation tissue or has retracted so far that it cannot be reached in case of emergency. Turning the patient over on his face, or, better still, upon the opened side, utilizes the weight of the mediastinal viscera to depress that structure toward the opened side; this, together with temporary closure of the opening either with the palm of the hand or a wad of gauze, is sure to afford relief. Within the next few hours either a permanent suction apparatus or a valvular drain should be improvised and fitted to the wound.

RETENTION. Retention is the result either of too high an incision or of too early removal of drainage.

In the former case, the diagnosis is made by so turning the patient that the drainage opening should constitute the most dependent point of the body (with the head lower than the hips), when a copious discharge of pus follows. By keeping the patient in this posture (most favorable for drainage) for a number of days it may be possible to avoid the necessity of making a counter incision — one must be guided by the temperature and the effectiveness of the drainage. If this postural method does not show good results within a day or 2, there should be no hesitation in making a counter drainage opening at the lowermost part of the empyema cavity. (See Postoperative Operations, Vol. II, Chap. III.)

If, a day or two after withdrawal of drainage, there is sudden cessation of discharge accompanied by fever, and change in posture (as just described) gives no relief, cautious insertion of the finger within the chest is the least risky method of locating the dammed back collection of pus.

To favor expansion of the lung as soon as a recently formed empyema has been drained, the patient is given James bottles with the order to blow as much and as often as possible.

Recently, positive pressure applied by means of a face mask several times a day has been used for the same purpose.

PERSISTENCE OF PLEURAL FISTULÆ. Persistence of pleural fistula may be caused by maintenance of tube drainage for too long a period (as a rule, the tube can safely be removed at the end of 10 or 12 days), or may be due to the presence of a foreign body (tube, gauze) which has slipped unnoticed into the pleural cavity. Meanwhile the external opening may have become too narrow to permit the extrusion of the foreign body.

OLD EMPYEMA CAVITIES. The treatment of old empyema cavities is aimed at their obliteration in 1 of 2 ways: Either the lung is allowed to expand after decortication of the thickened membrane which covers it, or the chest wall is mobilized so that it sinks in and comes in contact with the shrunken lung ("collapse therapy").

For operative treatment of old empyemata, see Thoracic Surgery, Vol. III, Chap. XI, and Postoperative Operations, Vol. II, Chap. III.

BONE FISTULÆ.—The ends of the resected ribs often become the seat of a localized osteomyelitis which causes the persistence of a sinus long after the empyema itself has healed. Infection may be prevented by protecting the resected ends of the rib with small packings of iodoform gauze before opening the empyema and flooding the wound with pus. These packings are to be left in place for a week or so; their ends are led out upon the skin, well beyond the margins of the wound, and fastened down with a few bits of sterile adhesive plaster.

Operations on the Chest Wall.—Operations on the chest wall (resections, osteoplastic exposures) are increasing in frequency since the adoption of intratracheal insufflation. Both primary tumors and local recurrences after breast amputation for carcinoma are now excised without subjecting the patient to unusual risks. In addition to this, the recently developed "collapse therapy" of unilateral pulmonary tuberculosis includes, among its measures, partial resection of the thoracic wall.

The pain after such operations is said to be more severe than after laparotomies. Zaaijer has pointed out that this is particularly true of cases in which the ribs were simply divided. He has shown that excision of small segments of the ribs will prevent contact of the cut surfaces and their painful friction caused by the respiratory movements.

Bandaging of one side of the chest without compressing the unaffected side is important. The accompanying illustration shows Sauerbruch's method of obtaining elastic compression of one side without embarrassing the other (Fig. 8, A and B).

THORACOPLASTY FOR PARTIAL COLLAPSE OF THE CHEST WALL (UNILATERAL PULMONARY TUBERCULOSIS). For the first few days an attendant must constantly be with the patient and must watch for the slightest rattling indicating an accumulation of secretion. Whenever this occurs, the patient must be made to cough out the mucus; this prevents aspiration into an uninvolved part of the lung. Embarrassed respiration is relieved to a great extent by elastic compression over the operated side. The posture should be the sitting one.

For the first few days high temperatures with no sputum are the rule. Later there is copious expectoration. From this on the degree of fever and the amount of sputum parallel each other. Fever persisting for more than 12 to 16 days is of bad prognostic significance (Sauerbruch).

Careful notation of the weight curve affords still another means of determining the general course of events.

The patients should be encouraged to get up as soon as they feel able. This is usually at the end of a fortnight.

There seems to be a greater tendency to the development of lateral curvature of the spine after the older type of thoracoplasty than after the recently devised operations.

General Remarks on Intrathoracic Surgery.[1]—Intrathoracic surgery, in spite of recent advances, is still largely in an experimental state. There is a great deal to be ascertained about the causes of cardiac insufficiency after operations upon the intrathoracic organs under differential pressure. It has been observed that the heart regained much of its power if the operation was temporarily suspended as soon as the appearance of deficient circulatory action was noted, and normal pressure conditions were established within the chest by closing the wound of the chest wall for a short while. Thus the operation could be resumed, to be interrupted again upon reappearance of symptoms (J. B. Blake). Death may come on within a few hours or even as late as 5 days after operation

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[1] See also Vol. III, Chap. XI.

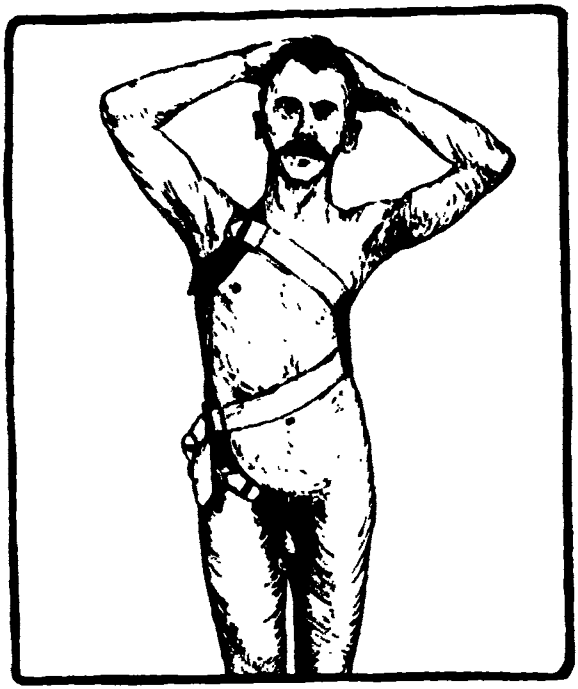

FIG. 8A.—BANDAGE FOR UNILATERAL THORACOPLASTY. Front view

Without warning, the blood-pressure sinks steadily, there is no response to stimulation, and, in spite of all measures, the downward course continues to the end. The respiration meanwhile remains comparatively unaffected. At present we do not know the causative factors of this phenomenon. Garre says:

> "There is no doubt that long operations under differential pressure are accompanied by dangers, which so far have not been accorded their proper recognition. Many operators must have had the experience that, after a long operation under differential pressure, death occurred either toward the end of the operation or shortly afterward. This fatal outcome could not be attributed to bad narcosis, hemorrhage, or aspiration. Ignorance of the actual cause of death has led these cases to be classified as 'fatal shock.'"

The utmost gentleness should be employed in operating upon the intrathoracic organs. Flint (3) has shown that manipulations caused prompt fall of blood-pressure, the degree of which was directly proportionate to the amount of trauma inflicted.

DRAINAGE.—It has been found that after any extensive intrathoracic operation a plentiful serous effusion almost invariably occurs. The unavoidable drying and handling of the pleura has been ascribed as the cause. (Carrel uses sheets of Chinese silk impregnated with liquid vaselin to protect the pleural surfaces. Tuffier does likewise.) Be that as it may, at first failure to provide an outlet to the effusion resulted in a number of deaths. Various methods of drainage were then tried. It was found that drainage by means of tubes, with or without valvular attachment, was invariably followed by infection of the pleural cavity, often with a fatal outcome. On the other hand, simple aspiration of the effusion upon the first or second day usually sufficed. A second aspiration was rarely necessary.

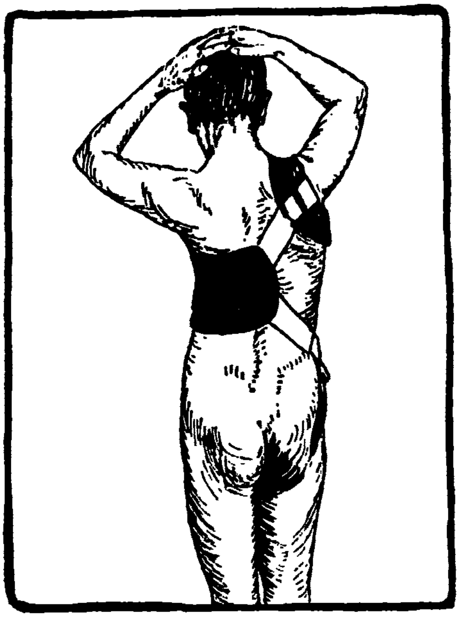

FIG. 8B.—BANDAGE FOR UNILATERAL THORACOPLASTY. Rear view.

Purulent effusions of the pleura require better drainage facilities than are afforded by repeated aspiration, even if this is combined with injection of some antiseptic solution. (Formalin injection is exceedingly painful and unsatisfactory.) For details, see Empyema.

HEMOTHORAX.—Hemothorax rarely occurs after intrathoracic operations. If the signs of internal hemorrhage do not increase and there is no embarrassment to respiration, the patient should be left alone. If there is fever, and the needle shows blood but no pus, there is no need of doing anything radical. The blood is absorbed in time if a true hemothorax is actually present. It may take weeks before the temperature reaches the normal standard. Meanwhile, the general condition remains excellent.

Operations on the Lungs.—PNEUMECTOMY.—In addition to the dangers of infection at the time of operation, and to those from a sudden pleural effusion within the first or second 24 hours after operation, there is, from the fifth to the seventh day, the danger of leakage from the stump of the bronchus. In this case a sudden change from a quiet, satisfactory condition to one of the most extreme gravity sets in. As a rule, death speedily supervenes in spite of anything which may be done. For prevention of this complication, see the technic of resections of the lung, Vol. III, Chap. XI.

LUNG ABSCESSES.—Lung abscesses, once they are drained, usually heal without complication. Occasionally a bronchial fistula develops; while this should be kept plugged with a gauze packing, the greatest care must be taken to avoid contact with the bronchial mucosa, as this causes incessant coughing.

PULMONARY FISTULA.—A simple way of distinguishing a pulmonary from a pleural fistula is this: Have the patient expire as deeply as possible and then lay the wet palm over the opening. After several deep inspirations and expirations, remove the hand toward the end of expiration. If air escapes, the fistula is pulmonary. Large pulmonary fistulæ may give rise to a great deal of distress. Laying a sheet of rubber dam over the skin opening and holding it there with a firm bandage gives great relief.

Operations on the Intrathoracic Portion of the Esophagus.—CARCINOMA.—The fate of the patient is usually determined by the operative technic, the postoperative treatment having very little bearing upon the final outcome of the case. So far intrathoracic union by suture after resection for carcinoma has not succeeded. The suture line has invariably leaked, and the patient has promptly succumbed. Blind closure of both ends has been equally unsuccessful, the blind upper end has leaked no matter how surely closed by superimposed purse-string sutures. The lower end has never given any trouble. Removal of the upper end from within the thorax has been the only method which thus far has resulted in preserving the patient's life.

DIVERTICULA.—Intrathoracic esophageal diverticula may follow organic conditions (benign or malignant stricture) or may occur without any ascertainable anatomical change as their cause (cardiospasm). In the latter case, the diverticulum has been found to persist after disappearance of all symptoms following appropriate treatment (Plummer's method for dilatation of the cardia).

Operations on the Mediastinum.—EMPHYSEMA.—Mediastinal emphysema or subcutaneous emphysema rarely follow anything but accidental injuries to the chest. Their treatment belongs to the domain of traumatic surgery.

It may, however, be well to mention the success Tiegel reported in a case of mediastinal emphysema of such severity that within a very short time both eyes were closed by the emphysematous swelling. An incision was made at the root of the neck down to the trachea; a Bier cup was applied and was connected up with a continuous suction apparatus. The emphysema promptly subsided, to recur as soon as the suction was discontinued. At the end of 5 days, however, it became possible to remove the suction apparatus. Uneventful recovery.

OPERATIONS UPON THE ANTERIOR MEDIASTINUM predispose, according to Sauerbruch, to the formation of thrombi.

ACUTE MEDIASTINITIS is an extremely fatal complication. Prompt operative intervention (establishment of drainage) will afford the patient his only chance of recovery (see Postoperative Operations).

TRENDELENBURG'S OPERATION for removal of emboli blocking the pulmonary artery has never been completely successful. Some of the patients have survived as long as 20 days. Death has been caused by infection owing to unavoidable hurry at the time of operation, pneumonia, pulmonary infarct, and recurrence of embolism.

With greater experience there seems to be no reason why certain favorable cases should not ultimately be successful. The wound in the pulmonary artery has always healed well.

THE ABDOMEN

GENERAL CONSIDERATIONS

It may be repeated that the discomfort of the first 24 hours is greatly alleviated by administration of fluid according to one of the standard methods, the least uncomfortable of which is the Murphy proctoclysis. Only after the postanesthetic vomiting has ceased a number of hours is it wise to allow fluids by mouth. These should be given as hot as possible. (Hot fluids are much less apt to cause return of nausea than the customary ice water.) Milk, because of its tendency to fermentation, should not be given until the patient's digestion has regained its normal tone.

Vomiting.—If vomiting persists longer than a few hours after narcosis has ended, the stomach should be washed out. Adherence to this rule at the Mayo Clinic has so reduced the number of acute dilatations of the stomach that this complication occurred only twice or 3 times in a series of over 4,000 laparotomies.

Pain.—Morphin is the only drug which really alleviates postoperative pain.

Certain surgeons of eminence withhold the drug and permit their patients to suffer, because of its tendency to produce distention. This view is not altogether correct; if peristalsis is induced by enemata before distention becomes marked, there is little chance of trouble from this source. In other words, there is no harm in using morphin, providing the first evidences of distention are promptly treated by suitable means.

To repeat briefly what has been dwelt upon at greater length in the preceding chapter, it is well to make sure that the pain is not caused by something other than the necessary injury of the tissues by operation, such as too tight a binder, an overdistended bladder, a drainage tube projecting too far beyond the surface of the skin, or a safety-pin transfixing skin as well as dressings.

Urinary Tract.—**The treatment of urinary retention and the common postoperative changes in the urine are fully discussed in the preceding chapter and in this chapter under the section on the Genito-urinary Tract.**

Alimentary Tract.—The treatment of distention, by emptying the large intestine and the stomach, has also been fully dwelt upon. It may do no harm to repeat that a cathartic should never be administered until one is sure that no obstruction exists, a fact readily ascertained by administration of enemata. The passage of flatus is often the first sign of the return of normal peristalsis.

When postoperative ileus comes on immediately after operation, it may be very difficult to determine whether it is due to simple inactivity of the gut or to an actual mechanical hindrance. When the ileus develops after a period of comparative well being, the diagnosis is clear. In any case, if the measures for reducing distention are competently and faithfully carried out with no effect, operation should be resorted to without waiting until the patient is in extremis. The character of the previous operation, the local findings, the type of the obstructive symptoms, and, above all, the patient's statements as to the location of most pain, help in diagnosing the site of obstruction.

The presence or absence of fever is only of relative aid in differentiating the ileus of peritonitis from that due to mechanical obstruction.

Diet. Unless there are special indications to the contrary, solid food is allowed by the fifth day (see preceding chapter). A previously healthy person needs no food for the first few days after a major operation, provided that enough fluids be given.

Care of the Wound.—The treatment of the wound, including the management of binders, removal of sutures, evacuation of serous effusions, drainage, the time for getting up, and the rupture of aseptically healed wounds have all been fully treated in Chapter I.

In elderly people the danger of hypostatic congestion of the lungs is so great that it is of the utmost importance for them to sit up as soon as they have come out of their narcosis; in other words, it is of greater importance to keep them alive than to avoid postoperative hernia.

If a large postoperative hernia develops in the course of healing by secondary intention, it should be attended to as soon as the tissues have sterilized themselves, i. e., as soon as the wound has healed. The tissues and normal tissue planes are much more easily recognized then than later.

A binder should not be worn unless the wound has healed by secondary intention, or the abdominal walls are lax after the removal of a large tumor or because of a visceroptosis. The binder or belt should be applied with the patient lying flat upon the back with hips clear from the bed. Rounded straps, passing from behind forward between the legs, prevent the belt from slipping upward.

Drainage, if pulled out immediately following operation, necessitates reopening of the wound if its replacement is indicated (see Vol. II, Chap. III).

Peritonitis.[1]—After the operative measures are concluded, the treatment of peritonitis narrows down to certain well established measures, namely, Fowler's position, nothing whatever by mouth, administration of fluids by proctoclysis. If vomiting occurs, the stomach tube should be used without hesitation, and it should be passed at intervals if there is any reason to believe that there is a re-accumulation of contents. Fowler's position and the Murphy proctoclysis have been described in the preceding chapter.

Postoperative peritonitis may arise from a number of causes. Diffuse peritonitis, with intense prostration, rapidly terminating in death, follows gross infections at the time of operation upon a previously uninfected field (many of the deaths from peritonitis within 12 to 24 hours are wrongly ascribed to shock).

The rupture of a large abscess flooding the peritoneal cavity with much infectious material causes such profound toxemia that survival is rare.

Late peritoneal infections from leakage from suture lines or from Murphy button anastomoses rarely occur earlier than the seventh day and from then on to the fourteenth day or even later.

Catgut infections are also late; an uneventful convalescence is suddenly interrupted as late as the second or third week by suppuration in the operated tissues.

Residual abscesses make their appearance in the second or third weeks after operations for diffuse peritonitis. The operative treatment of these is discussed elsewhere under Postoperative Operations, etc. They should always be suspected in any diffuse peritonitis when the fever does not completely subside within a short time. Under these conditions daily pelvic as well as abdominal examinations should never be omitted.

Inanition.—In contrast to previously healthy patients who promptly recover their former condition, individuals with marked inanition or cachexia before operation do not regain physiological equilibrium except by very gradual stages. Their lives hang by a mere thread, they fall an easy prey to any complication such as hypostatic congestion, bronchitis, diarrhea, etc., and it is only by the most careful nursing and watchfulness, together with a certain amount of good luck, that they finally regain health.

Each case is a rule unto itself. In general, subcutaneous infusions of grape sugar in distilled water are to be used to tide over the first few days. Rectal feeding belongs in the same category. When gastrostomy has been done under local anesthesia, nourishment may immediately be introduced into the stomach; the same holds for jejunostomy[2] or cecostomy (appendicostomy) established for the sake of the nutrition. When the operation has been done under general anesthesia, the administration of food by mouth must be delayed a little (here the subcutaneous method is of the greatest aid). At first small frequent feedings should be made (1 every 2 or 3 hours) of only the most concentrated and easily digestible material, such as albumen water, or whey; the amounts of these can quickly be increased if well borne. Later raw eggs beaten up in milk and similar material are added; then a little chopped meat, and so on up the list.

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[1] See also Vol. IV, Chap. X.

[2] Garré particularly recommends jejunostomy in emaciated stomach cases for improving the general condition sufficiently to warrant performing a radical operation.

Inoperable Conditions. After exploratory laparotomy at which inoperable conditions are revealed, the patient should not be robbed of hope by a bald statement of what was found. Occasionally the spontaneous disappearance of an "inoperable" tumor surprises the surgeon, proving that an inflammatory condition was mistaken for a neoplasm. Unfortunately this is but rarely the case. As a rule, the tumor and ascites increase, and death only comes on after months of misery.

One of the greatest needs of the present time is the establishment of a number of hospitals for the care of such unfortunates. The average general hospital in a city refuses to readmit these people, once they have left shortly after the healing of their laparotomy wounds—and rightly, too, because such a hopelessly diseased individual will then occupy a bed which might otherwise accommodate one for whom something can be done. For this reason special provision should be made for the care of such cases in an institution adapted to their needs. In the later stages, after they have acquired a tolerance for morphin, the division of sensory nerves or of the pain-bearing sensory (anterolateral) tracts in the spinal cord often relieves their suffering during the remainder of their lives.

Tuberculous Disease. All cases of tuberculous intra-abdominal disease should undergo a course of sunlight treatment after their wounds have healed or after they have recovered sufficiently to be transported. The results obtained by Rollier in Leysin have been confirmed by others, and this treatment has now become the one of choice.

Cysts which cannot be extirpated are drained and allowed to heal by granulation. This takes a long time and requires considerable care from the very beginning. The strictest asepsis must be maintained to prevent infection. The best protection is a voluminous gauze dressing changed frequently and with the utmost care. A drainage tube keeps the external opening from narrowing too much; it should not be disturbed for at least 2 weeks. Nothing should be introduced into the cavity from the outside—there is no sense and no advantage in irrigating such a cyst. The skin, especially in cysts of the pancreas, must be protected from the very first by a coating of zinc oxid paste covered with sterile rubber tissue. Permanent suction drainage is of the utmost value. By means of it the skin can be kept dry of secretions which irritate. Drainage can also be improved by placing the subject in the sitting or prone, or lateral posture. At the end of a fortnight the drainage tube is replaced by one of smaller caliber. The interior of the cyst may be treated with silver nitrate or iodin to stimulate granulation. Echinococcus cysts are often sterilized by weak solutions of formalin. If a sinus persists, its removal is subject to the general rule of first exposing normal structures nearby and only then proceeding toward the tract which is to be removed.

THE LIVER AND BILE PASSAGES[1]

Ideal cholecystotomy is occasionally done in selected cases of cholelithiasis. Convalescence is shortened through primary closure. If no stones have been overlooked, the end result leaves nothing to be desired.

Biliary Fistulæ.—In most cases a biliary fistula is established.

Remember that bulky drainage has been known to press upon the duodenum, causing acute dilatation of the stomach, which promptly subsided upon withdrawal of some of the packings.

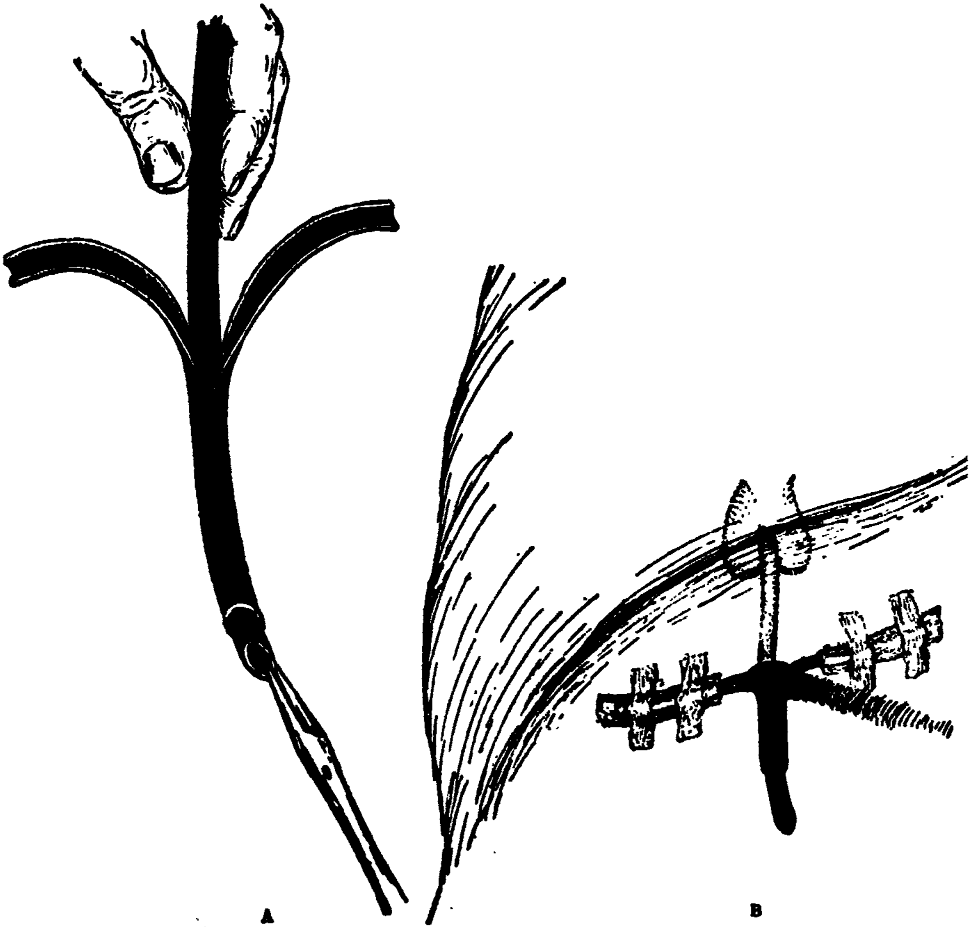

Fig. 9.—A Method of Draining the Gall-Bladder. A, The inner tube is put on the stretch while the outer (split) tube is slipped over it. B, Drainage in place; ends of the split tubing attached to the skin with adhesive plaster.

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[1] See also Vol. IV, Chap. IV.

The drainage tube from the gall-bladder or common duct has its outer end connected with a bottle by means of a glass connecting tip and a length of rubber tubing. The amount of bile discharged in 24 hours is charted by the nurse.

To prevent the tube from being dislodged by chance movements of the patient, it must be firmly held in its proper position. Two ways may be mentioned: A safety-pin transfixing the tube at the level of the skin may be fastened down with long strips of adhesive plaster. A split compress of gauze protects the skin from contact with the pin, more gauze is added superficially to the pin, and the entire dressing is held in place by adhesive straps and a firm binder. Another way of securing the tube is shown in Figure 9, A and B. Just before the drainage is inserted at operation a piece of tubing about 8 in. long, of slightly larger caliber than the one to be used for drainage, has one end split to within 2 or 3 in. of the other end. A clamp, passed through the intact remainder, seizes the end of the actual drainage tube, which is then put on the stretch and consequently becomes thinner; the partly split tube is now slid down the thinned out tube to any desired spot. As soon as this is reached, the inner tube is relaxed, assumes its normal diameter, and crowds against the outer tube and thus becomes firmly fixed to it. When the drainage tube lies in place, the outer split tube should have its split end a little higher than the skin. Adhesive fastens the halves of the split to the skin.

The dressings are not disturbed for 10 days. By this time it is usually safe to remove the tubing (the anchoring catgut stitch has become absorbed). If there is the slightest resistance to gentle traction, wait a few days and try again—do not pull it out. As long as there is no retention it makes little difference whether gauze or rubber drains come out a few days sooner or later.

After operation for acute infections of the bile passages drainage must be maintained until the bile becomes permanently clear.

Upon withdrawal of tubing, the bile naturally flows out upon the skin, which should be protected against irritation by a liberal coating of zinc oxid ointment. The profuse biliary discharge is best absorbed by pads of Irish moss covered by gauze.

If the lower bile passages are free, the outer opening should close in from 3 to 6 weeks. The patient should be instructed to expect the biliary flow to start again several times after it has apparently ceased for good, otherwise he is apt to be too elated at its first cessation and correspondingly depressed at its reappearance.

Obstruction of the Common Duct.—A very profuse discharge of bile from the fistula, plus acholic stools, indicates obstruction of the common duct; there may be a number of causes for this. The commonest is, of course, stone, less frequently a tumor. Tumors of the common duct are frequently associated with stone; the latter may so occupy the operator's attention that the former escape notice. *Cicatricial stenosis* following ulceration of the common bile duct is another cause for obstructive symptoms. Nowadays no one sutures the gall-bladder to the parietal peritoneum (experience has shown that there is no danger from leakage), so kinking of the common duct from this cause no longer occurs. (See, however, Operations on the Liver, etc., Vol. IV, Chap. IV.)

With a persistent fistula and acholia, it is desirable to test the permeability of the common duct; if colored stools are observed after plugging the fistula with a gauze tampon, there is no obstruction; if a typical gall-stone colic with fever and persistence of the acholia follows, obstruction surely exists.

Profuse discharge of bile for longer than a week or 2 is apt to cause serious depreciation in general condition. Attempts to have the patient swallow his collected bile have been failures, as it was impossible to swallow much of the bitter fluid. On the other hand, administration of 500 c. c. of bile twice a day by stomach tube has been kept up for weeks to the great benefit of the patient (Schmilinsky).

As soon as the general condition permits, a second operation must be performed at which either the existing obstruction is removed, or a new communication with the intestinal canal is established.

All artificial anastomoses of the bile passages with the gut are sooner or later followed by ascending infection and death. It makes little difference whether the operation was a cholecystenterostomy, a hepaticoduodenostomy, or what not, the end result is the same.

Obstruction of the Cystic Duct. In some cases of cholecystostomy no bile escapes from the drained gall-bladder although the stools are normally colored. The fistula discharges mucus. As a rule, a stone is blocking the cystic duct; less often the duct is obliterated by scar tissue. It may be possible to determine the cause of obstruction either by sounding with a blunt probe, by introducing the finger into the gall-bladder, or by the use of a speculum. Eventually a secondary removal of the diseased gall-bladder may be the only means for doing away with the fistula.

Gangrene of the Mucosa.—If the mucosa of the gall-bladder is gangrenous, there is strong probability of its ultimate obliteration (healing by granulation), provided the patient lives long enough. In less favorable cases many foci of suppuration are present in the walls of the gall-bladder, drainage only relieves the condition to a slight extent, there is a long-drawn out illness, and either the small abscesses eventually point into the drained tract and healing takes place, or there is a steady downward course—at times this may be checked by secondary cholecystectomy; at others the patient is too far gone to recuperate.

Cholemic Hemorrhage.—Cholemic hemorrhage formerly was one of the gravest and most fatal complications. It usually comes on at some time between the seventh and fourteenth days. If sufficient quantities of normal blood elements are promptly administered, the oozing will be checked. In the milder cases normal blood-serum (diphtheria antitoxin, i. e., horse serum, is the most ready at hand) subcutaneously injected often suffices. If not, the subcutaneous injection of 100 c. c. of defibrinated human blood should be tried before resorting to the sovereign remedy of transfusion. The administration of calcium chlorid or of gelatin is of no value.

Enteroclysis by Way of the Common Duct. McArthur has connected a salin drip to a drainage tube lying in the gall-bladder, allowing the water to find its way into the duodenum by way of the cystic and common duct. Matas modified this by introducing a ureteral catheter along the bile passages into the duodenum. The procedure has found favor with these authors in toxic biliary cases.

THE STOMACH[1]

Gastrostomy. If the gastrostomy tube has been pulled out within a few hours, or even a few days of operation, the wound must be reopened sufficiently to permit replacement of the tube under the guidance of the eye. I know of scattered instances in which the tube was blindly replaced, supposedly into the lumen of the stomach, actually into the peritoneal cavity; introduction of milk caused a fatal peritoneal sepsis and death within a few hours.

If the operation has been performed under local anesthesia, fluids can immediately be given through the fistula. To avoid overloading the greatly shrunken stomach, they are given in small quantities at frequent intervals. The stomach's capacity will gradually increase. A commonly used method is for the food to be first chewed finely and then placed in a funnel attached to the gastrostomy tube. The nourishment improves, but never to the degree observed after gastro-enterostomy.

In benign strictures of the esophagus, the rest afforded by a gastrostomy often results in the gullet again becoming permeable. The methods for dilating such strictures are described in Vol. IV, Chap. II. Malignant strictures require no special mention.

LOCAL MANAGEMENT OF THE FISTULA. After the Kader-Senn or Witzel methods, it is unwise to remove the tube until 7 to 10 days have passed. The tube must be worn continuously; if left out for only a few hours, it may be impossible to replace it, even if several months have passed since the operation. After the Depage or Janeway methods, the tube can be left out with impunity because the fistula is lined with mucous membrane instead of with granulation tissue; in fact, with these the tube is only inserted at feeding times.

Leakage from widening of the fistula is an extremely difficult condition to deal with. If the insertion of a larger tube fails to stop the leak, and if, furthermore, the employment of a rubber flange tube, like some used for the drainage of empyema cavities, also fails, the method of von Hacker may be successful. This consists in passing 2 subcutaneous loops in opposite directions around the fistula's mouth and drawing upon them after freshening its edges (see Postoperative Operations).

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[1] See also Vol. IV, Chap. II.

Gastric Resections.—In the presence of postoperative stagnation there should be no hesitation in passing the stomach tube. There is no danger of harming the freshly made suture line, and the relief afforded is great. After the distended stomach has been emptied, the patient should be kept lying upon the right side (as recommended for years by Kocher).

LEAKAGE.—This has most frequently come from the duodenal stump. If the proper technic is used, there should be no leak; the Mayos report using the method of Willy Meyer of closing the duodenal stump for the past 7 years without experiencing trouble.

In former years, if an operator was doubtful about a suture line in a hollow viscus, he led a piece of gauze wicking down to the suspected spot; this was carefully pulled out after a few days and it was a miracle if a fistula did not develop, for the gauze by that time was firmly embedded in granulations which were torn loose upon its removal.

GANGRENE OF THE TRANSVERSE COLON from inadvertent ligation of the colica media artery at operation is a very rare accident. It has been shown in a number of cases that the colica media can be ligated without disturbing the vitality of the transverse colon.

Gastro-enterostomy.—This is still the most frequently performed operation upon the stomach. Hence the treatment of its complications will be discussed a little more fully than those of other operations.

HEMORRHAGE.—Hemorrhage may come from either the posterior suture line or, in cases of bleeding ulcer, from the ulcer for which the gastro-enterostomy was performed. Men of sufficiently large experience have stated that it is merely a chance whether the bleeding from an ulcer stops after gastro-enterostomy, that is, in the greater proportion of instances the hemorrhage stops, while in a considerable minority it continues and the patient bleeds to death, irrespective of the operation.

Washing out the stomach has been followed by cessation of hemorrhage in a number of instances, the idea being that if the stomach is filled (with blood and clots) its walls are more or less stretched; as soon as the organ becomes empty it contracts, and this contraction may constrict the mouth of the bleeding vessel a little—just enough to enable a coagulum to become established.

LEAKAGE.—Leakage may occur at the time of operation or a week or 10 days later. The late leakage almost never occurs after a suture anastomosis. Individuals with tertiary lues, however, seem particularly prone to suffer a leak from their anastomosis line about the tenth day. Late leakage has followed Murphy button anastomosis where no purse-string sutures around the neck of the button and no Lembert sutures were put in as additional protection, but this is rare.

VICIOUS CIRCLE.—Nowadays this complication is much less frequent than formerly, owing to the widespread adoption of the posterior short-loop (so-called no-loop) anastomosis.

The protracted vomiting of large quantities of bile-stained fluid led to the belief that the presence of bile in the stomach was pathological and was perhaps the cause of the vomiting. Further experience has shown that bile is regularly present after a properly performed gastro-enterostomy, and that it does no harm and is not the cause of "vicious circle."

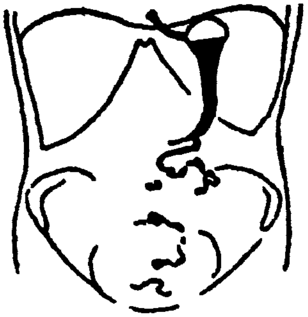

Fig. 10.—Discomfort after Meals in a Patient with a Gastro-enterostomy. Material immediately escaping from the stomach and distending the upper jejunum. (Hertz.)

If protracted vomiting is not controlled by frequent lavage and postural treatment, do not wait until the patient is exhausted before reopening the abdomen and joining the afferent to the efferent loops of the small intestine.

Rarer Complications. Intestinal Obstruction from Herniation of the Small Intestine through the Opening in the Transverse Mesocolon.—If the opening in the transverse mesocolon is not sutured either to the stomach or to the actual site of anastomosis, there is danger from this complication.

Inflammatory Tumor Involving the Stoma.—This may cause so much trouble that a second operation may be necessary to give relief.

Narrowing of the Stoma.—This has been found to occur after button anastomoses. Whether the newer oval button will prevent this cannot be determined at this early date. Narrow stomata after suture anastomoses have been found at secondary operations. Trend of opinion indicates that this was because the operator failed to make a large enough opening, rather than because of a cicatricial contraction.

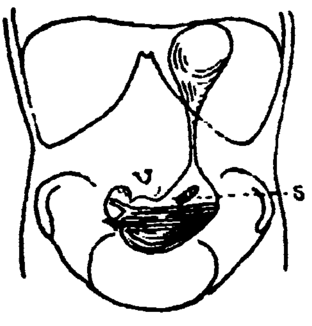

Fig. 11.—Discomfort after Meals in a Patient with a Gastro-enterostomy. The stoma is high up on the posterior wall of a greatly dilated stomach. In the upright posture food simply stagnates. (Hertz.)

Discomfort after Meals.—A. F. Hertz has described 2 causes for this in people who have a gastro-enterostomy. In some, the meal was seen (by the X-ray) to leave the stomach almost as quickly as it entered, and the discomfort was due to the overloading of the upper jejunal loops (Fig. 10). In others, there was gastric stagnation because the stoma lay well up on the posterior wall of the stomach and the gastric contractions were insufficient to empty the stomach through this opening (Fig. 11).

Small amounts of food at frequent intervals and lying down for a time after meals helped those cases with over-rapid emptying. A good abdominal supporter and a siesta after every meal helped the others.

Jejunal Ulcer.—The patients who have been operated upon for gastric or duodenal ulcer must be impressed with the fact that their tendency to have ulcer has not been removed by operation and that, as long as they live, they must observe dietary and hygienic precautions. The best examples of this tendency to ulcer are the recurrent gastrojejunal ulcers which sometimes require 3 or 4 operations.

After operations for *gastric carcinoma,* there is frequently great improvement even in those upon whom only a palliative operation has been done. They may enjoy several months of good health before the carcinoma makes itself felt again.

Pyloric Exclusion.—To a certain extent, this operation is still in the experimental stage. The original method of von Eiselsberg, dividing the stomach completely across and closing both ends blindly, has the disadvantage of taking considerably longer than a simple gastro-enterostomy, and the mortality is consequently somewhat higher. For this reason a host of substitutions have been devised which are too recent to have stood the test of time. Among these the string method of Parlavecchio has been shown to result in the string's cutting through with re-establishment of the pyloric lumen; Wilms' constriction with a strip of fascia has been found to give rise to a mass of dense adhesions. In short, the ideal method has not been evolved.

Duodenal fistula is a rare but extremely grave complication. Its management is described under treatment of high intestinal fistulæ (see Intestine).

Operations for Gastroptosis.—Operations for gastroptosis (Beyea's, Rovsing's, Coffey's) may be followed by great subjective relief or, with identically the same clinical picture, there may be temporary relief, followed by recurrence of the old symptoms. (When this occurs, the patient is dubbed a neurasthenic.) This class of cases can derive much benefit from proper medical supervision in a well conducted sanitarium. They belong in the same class with the cases of so-called coloptosis, the surgical treatment of which has not been sharply defined. One thing, however, is definite, gastro-enterostomy for gastroptosis is no longer practiced by competent surgeons.

HERNIA[1]

The after-treatment varies according to whether a radical cure was made upon a reducible hernia or, if the hernia was irreducible, whether its contents were viable, in a doubtful state of viability, or undoubtedly gangrenous.

Radical Cure.—For the treatment of serous subcutaneous effusions in a wound, the different layers of which have healed by primary union, see the preceding chapter. Moderate hematomata are best left alone, they will absorb in time. Swollen testes are oftener the result of operative trauma[2] rather than lack of support by the dressings as advocated by those who favor the employment of the cross perineal bandage.

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[1] See also Vol. IV, Chap. 1.

[2] By this is meant too rough handling of the cord, too tight closure of Bassini sutures around the cord constricting it, or similar obstruction to circulation from suture of the external aponeurosis.

This cross perineal bandage (Fig. 12) is in effect a double spica. After starting at any convenient point, the essential part of the bandage consists in a turn which begins over one anterosuperior spine, passing obliquely downward and to the opposite side, across the inguinal region of that side, around the outer aspect of the thigh to its posterior aspect, from where it crosses the perineum to the same side from which it started, covering over the inguinal region of that side before reaching its starting point. It then passes around to the back to start a similar loop on the other side. This bandage brings pressure to bear on the inguinal regions and, at the same time, supports the testes. The penis is brought out through a sheet of rubber tissue with a hole in its center, held in place by the last few turns of the bandage.[1]

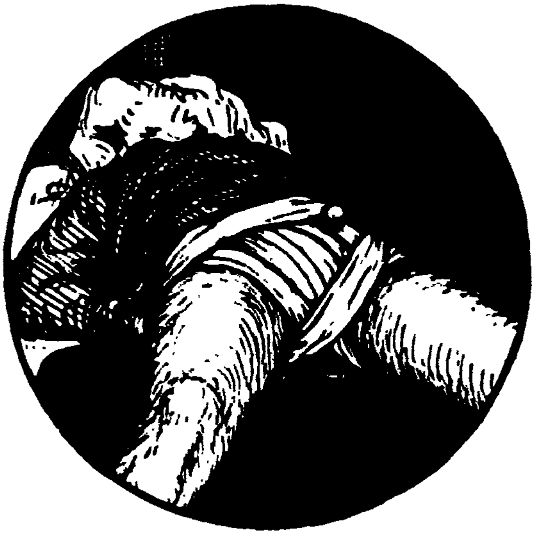

FIG. 12.—CROSS-PERINEAL BANDAGE. (A. G. Gerster.)

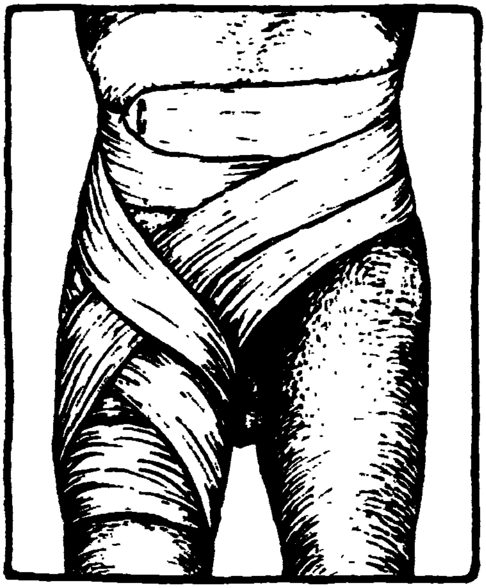

FIG. 13.—SPICA WITH EXTRA TURN AROUND THIGH TO PREVENT UPWARD DISPLACEMENT.

A simple spica bandage tends to slip upward and to cut into the groin; this displacement can be prevented by taking an extra turn around the thigh before completing the spica's turn (Fig. 13). In putting on these bandages, the thighs should be slightly flexed on the trunk. When the patient is in bed the legs straighten out, bringing additional compression upon the wound in the inguinal region. If the flexion is too marked or the bandage too tight, it will cut into the posterior aspect of the thigh. After consciousness has been regained, it is well to slip one's hands under the bandage to make sure that the proper degree of pressure has been established.

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[1] The turns of bandage adjacent to the penis must be secured by safety-pins where they cross each other.

If there is the slightest danger of the dressings' slipping, as for example in very stout people, or in restless children, or in women after either femoral or inguinal herniotomies, it is safer to secure the margins of the gauze dressings to the skin with rather broad adhesive strips, half of which are in contact with the skin, the other half with the gauze. The bandage tends to slip outward, exposing the inner portion of the wound; the adhesive is applied along the labium majus from in front backward.

In small children, the wound must be protected from urine. The safest way of accomplishing this is to apply a collodion dressing or to glue the margin of a sheet of rubber tissue to the skin between the genitalia and the wound. This protects the gauze dressings and, with them, is held in place by the bandage. In male children, the penis may be drawn through a hole in the center of a sheet of rubber tissue as in the case of male adults. But this is not suitable for very small infants.

In herniæ of moderate size, the patients get up at the end of 14 days. After repair of very large herniæ, it is better to keep them in bed for 21 days. No heavy lifting, or anything to bring on undue abdominal strain, should be allowed for at least 6 months. **A truss should never be worn, its pressure atrophies the tissues at just the spot where the greatest strength is needed.**

Granted that the operation was done perfectly, the end result will depend on the type of the patient's tissues; an old man with large weak rings and flabby abdominal muscles is far more apt to have a recurrence than a strong young man.

Incarcerated Herniæ with Intestinal Obstruction.—Here the main object of the operator is to save life. If a radical repair of the hernia can be done without extra danger to the patient, so much the better, but this is an incidental consideration. In some cases it will be possible to do an ideal operation, that is, relieve the constriction and repair the hernia; in others, the viability of the gut may be doubtful and it may be left out upon the abdominal wall from a few hours to as long as a day or 2, after which it is replaced within the abdomen and the wound closed except at one end for drainage; in still others, the gut is gangrenous and either a fecal fistula is established or, if the general condition is good, resection is made. For details, see Vol. IV, Chap. I.

The postoperative treatment in these cases narrows down to the treatment of shock, intestinal obstruction, and peritonitis. If obstruction persists in spite of treatment, the suspicion should arise that some band or other cause escaped recognition at operation, and the possibility of a second exploration must be considered.

THE INTESTINE[1]

The Management of Low Intestinal Fistulæ.—The skin is protected by a thick coating of zinc oxid ointment overlaid with a sheet of rubber tissue with a

[1] See also Vol. IV, Chap. VIII.

central hole a little larger than the fistula. The profuse discharges are caught in moss pads. Should an eczema occur, silver nitrate solution or paste is an excellent astringent.

Giving the patient a supply of gauze to catch the discharge and thus allowing the skin to dry is another way to improve matters. A permanent bath in exceptional cases may prove of service. **(Permanent suction is a valuable measure.—Editor.)**

RETENTION.—This is often seen after spontaneous production of a fecal fistula by the sloughing of a strangulated hernia. Through inadequate openings in the skin the discharges manage to escape; there is fever. By laying the tract wide open, the tendency to burrow is stopped, and the abscesses lying between the loops of intestine are freely drained.

CLOSURE.—Small fistulæ may heal by granulation, larger ones require surgical intervention.

Where the entire intestinal contents have escaped through the fistula, before attempting closure it is essential to ascertain whether the gut below the enterostomy is patent. This may be accomplished either by injecting colored fluids into the efferent loop, or by temporary closure of the opening, causing the intestinal contents to enter the lower loop.

For details of the surgical cure of fecal fistulæ, see remarks below, as well as Vol. IV, Chap. VIII.

The Management of Fistulæ in the Upper Small Intestine.—Through such a fistula practically all the fluid taken by mouth escapes, and an extremely rapid inanition sets in, which, if unchecked, kills within a few days or weeks. Either the opening in the intestine must be closed, or the escaping intestinal contents must be reintroduced into the alimentary tract by some other method. It may be possible to close the opening by inserting the ends of a T tube into either loop and then drawing upon it. The method of von Hacker (see Gastrostomy) may be tried. If the fistula lies at the bottom of a granulating wound, the skin can be united with interrupted silkworm-gut sutures, drains of rubber dam are inserted at either angle, and a firm compression is applied directly over the opening. This must not be done before granulations are present, because of the likelihood of burrowing. The intestinal contents may be collected and then injected into the efferent loop or they may be introduced into the large intestine either in the form of nutrient enemata (Schmilinsky) or through a right iliac colostomy. In the latter instance it may be feasible to join the upper to the lower fistula by means of a snugly fitting drainage tube.[1] If none of these makeshifts succeed, major surgery must be resorted to (see Postoperative Operations).

Duodenal fistulæ are among the most important of the group under discussion; they have followed operations on the gall-bladder, pancreas, and right kidney. They are best controlled by pyloric exclusion and gastro-enterostomy (A. A. Berg).

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[1] **Such a tube must be firmly anchored or it may pass on down the bowel and stop at a lower obstruction if such exists. (Editor.)**

The cutting through of an intestinal spur with special clamps, etc., is no longer done because of the danger of perforating the intestinal wall or injuring a second loop of gut.

Intussusception in Infants.—Nowhere are timely operation, gentleness, and rapidity of greater moment in reducing mortality than here. Upon leaving the operating room, the child may apparently be in good condition, and yet go into a gradual collapse in the course of a few hours. It is, therefore, advisable to resort to active stimulation on general principles for at least 12 hours after operation. Once the children are in collapse, they rarely respond to any therapeutic measures.

THE APPENDIX[1]

Nothing is simpler than the after-treatment of a clean appendectomy, i. e., one in which there is primary union with no secondary complications. Within a day or 2 the pain in the wound and the after-effects of the anesthetic have worn off, a few days later stitches are removed, and in a short while the subject is up and about.

On the other hand, nothing may so tax the surgeon's skill and ingenuity as the treatment of a complicated case of appendicitis. Between these 2 extremes come numerous intermediate types.

Local Infection of the Wound.—Occasionally there is local infection of the wound. Although the skin has united, there is a purulent exudate in the depths down to the peritoneum. In all probability, the fibrin-coated appendix (it is in this type of case that the complication occurs) has come into contact with the sides of the wound. The researches of Runeberg and, later, of Heyde, have shown that this fibrin is swarming with anaërobic organisms. Such an infected wound must be laid wide open and allowed to heal by granulation.

Drainage.—In doubtful cases, in which the surgeon would like to close the wound but does not dare to, he usually compromises by using a drain of rubber dam which is withdrawn on the second day. A wet dressing for a few days more completes the story. Should retention follow, the pus usually finds its way out along the drained tract after a day or 2 under hot applications and hot colon irrigations; this is a rare complication.

The actual appendix abscesses run a different course. For the first day or 2 there is no secretion; then a profuse discharge sets in. The superficial dressings must be changed 2, 3, or 4 times in 24 hours. At first the pus often has a fecal odor and color (the latter due to blood which has oozed into the abscess cavity immediately after termination of the operation), and the inexperienced mistake the condition for a fecal fistula. In 2 or 3 days the color changes to the common greenish-white hue and the odor loses in strength and pungency. As the discharge decreases, the drainage tube is shortened ($\frac{1}{2}$ in. at a time) and is replaced by a smaller tube (see section on Drainage in the preceding chapter). Practical experience alone can teach one how to avoid leaving drainage in too long or too short a time. If the hole established by the presence of drains is large, their removal even as early as the fifth or sixth day may be proper, there being no danger of retention. The filling of the wound with pure balsam of Peru at the end of the first week often markedly decreases the discharge within 24 hours. (This does not invariably follow, but it occurs often enough to justify mention.) If the skin shows signs of irritation, it should be liberally coated with a bland ointment (zinc oxid or boric acid).

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[1] See also Vol. IV, Chap. IX.

After drainage is out and the secretion is merely a scanty discharge, a boric acid ointment dressing suffices.

Delay of closure of the wound may be due to (1) the presence of a foreign body (a coprolith, a piece of necrotic tissue—viz., part of the gangrenous appendix left behind—an unabsorbed ligature, or a bit of drainage material—gauze or rubber) in which case the discharge is profuse and foul, or (2) it may be the consequence of maintaining drainage for too long a time, when the discharge is very slight, coming as it does from a rigid walled tract lined with scanty granulations. Very rarely it is caused by a pin point hole in the gut.

Treatment in the former case consists in enlargement and exploration of the suppurating tract and removal of the cause; in the latter, simple neglect of the tract—that is, a mere change of superficial dressings twice or 3 times a week—will just as often be followed by ultimate closure as too much meddling, in the form of repeated curettings and applications of iodin, silver nitrate, and similar stimulants. Should the sinus persist more than 6 months and be the cause of serious annoyance, it should be excised (see Postoperative Operations).

Fecal Fistula.—This is not a serious complication, spontaneous closure generally occurring in a week or 2 in the cases where the drainage is free (no retention with pain and fever).

Schmitz (11) reports the successful use of Trendelenburg's position in the cure of a fecal fistula of the cecum. In this posture, the opening in the cecum lies higher than the ileocecal junction and gravity causes the intestinal contents to flow toward the hepatic flexure, thus keeping the cecum empty and favoring closure of the fistula.

Hernia.—Should a hernia develop following drainage, wait several months after scarring is complete before operating; otherwise, one runs the risk of encountering minute purulent foci, thereby endangering the success of the operation.

Simple Drainage of Abscess Without Removal of the Appendix.—An appendix which has given rise to an abscess causes trouble until it is removed. In older abscesses, with thick smooth walls of fibrin, it may be extremely difficult to identify the appendix. It is, therefore, better to be content with simple drainage, reserving the actual appendectomy for a more suitable time. The more experienced the operator, the fewer the number of these secondary appendectomies, although no surgeon will entirely avoid them no matter how great his skill.

Secondary Hemorrhage from Erosion of Vessel Walls by Pressure of Drainage Tubes.—The vessels are the epigastrics and the common or external iliacs. In the former, while the hemorrhage is brisk, there is usually time to reopen the wound and control the bleeding; from the latter, the hemorrhage is so great that a fatal exsanguination is only a question of moments. There is a better chance of saving life if the hemorrhage occurs at the time of dressing (removal of deep drains).

Appendicitis with Diffuse Peritonitis.—It is impossible to predict the postoperative course by the local condition of the peritoneum. Cases in which one might expect a stormy convalescence, judging by the macroscopic appearance of the peritoneum, often run a smooth, uneventful course, while others, in which the findings are much less ominous, develop the gravest complications.

The immediate postoperative routine has been described at length elsewhere; briefly enumerated, it consists in Fowler's position and the so-called Ochsner treatment—nothing by mouth, gastric lavage if indicated by repeated vomiting, administration of water by proctoclysis (Murphy)—until the temperature and other untoward symptoms have completely subsided. As long as the patient receives enough water, there should be no hurry in commencing the administration of food.

Residual abscesses make their appearance during the second week. If there is persistence of fever not accounted for by the local retention or some respiratory condition, a residual abscess must be sought for. It may not be accessible to palpation for several days. Meanwhile hot rectal (colon) irrigations twice a day supplemented by heat (hot-water bag, or baking) to the abdomen may hasten matters. In the daily search for new physical signs, pelvic examination must never be omitted, the pouch of Douglas being the most frequent site for residual abscesses to form. The other sites, in order of frequency, are the left inguinal region, the right and left subphrenic spaces, and the right perinephric region.

Ileus.—Ileus may be due to simple paresis of the intestinal walls (dynamic ileus), a condition generally amenable to proper treatment if it is instituted early enough; or to actual obstruction by drainage material, adhesions, or bands formed by adherent omentum. Do not delay too long before reopening the abdomen in cases where a fair trial of the various methods for combating distention have failed. (See Vol. II, Chaps. I and III, for details of secondary laparotomy for intestinal obstruction.)

Icterus.—Coming on shortly after operation, icterus is an extremely bad sign. It betokens the presence of a severe intoxication, which usually kills in the course of a few days. In addition to the icterus, there often is a very high temperature with wild delirium, terminating in coma.

Gastro-intestinal hemorrhage is likewise a rare complication after operations for appendicitis. It is no more frequent than after other abdominal operations (see Vol. II, Chap. I). As said elsewhere, it may have its origin in a previously quiescent gastric or duodenal ulcer or in minute erosions in the mucosa of this region (see treatment of hematemesis by lavage and by exploration according to Rovsing, page 18).

Hematuria is usually right-sided. In the majority of instances the etiology is obscure and the condition subsides spontaneously after a few days.

Pylephlebitis.—Fortunately this very fatal complication is rare. As a rule, all goes well after the removal of an acutely inflamed appendix (the presence or absence of drainage is of no moment) until the end of the second week, when there is a chill and perhaps slight enlargement of the liver, with no other physical signs. The chills increase in frequency; the patient gradually succumbs to sepsis. Blood-cultures are constantly negative until just before death, when an agonal invasion of the blood stream takes place; they are of no diagnostic value. At post mortem, suppurative thrombi are found to extend from the veins of the appendicular region along the ileocolic vein to the portal, thence into the liver, which is studded with purulent foci, or there may be large hepatic abscesses.

In some exceptional instances the infection has gradually died out, but a year or 2 after apparent recovery, death has occurred as a result of portal obstruction from the cicatricial deposits laid down in the course of healing.

The only hope of saving life lies in early extirpation of the thrombosed ileocolic vein before the process has reached the portal vein. See Postoperative Operations.

THE RECTUM[1]

General Considerations.—Before any operation upon the rectum, if circumstances permit, the bowel should be emptied by a cathartic, preferably castor oil because of its tendency to be followed by constipation. The food should consist of fluids because they leave but little residue. Above every stricture the dilated and atonic gut is filled with a mass of stagnant foul material. The thinned-out intestinal walls are often the seat of ulcerations (Dehnungsgeschwüre in German), which may perforate. If the stricture is divided without first emptying the gut above it, the postoperative course is much complicated by the passage of intestinal contents past the site of operation. Often the material consists not only of fluid, but also of hard, inspissated masses of feces dislodged from crypts in the large intestine. If the stricture is not too narrow, it will be possible to empty the bowel by the usual means; if this cannot be done, a temporary colostomy affords the only means for accomplishing the purpose.

Operations for Inflammatory Conditions, Ischiorectal Abscess, Etc.—It is well to bear in mind that those inflammations situated anterior and superior to the rectum always have the possibility of spreading to the peritoneum. After incision and drainage of a periproctitic infection it is proper to keep the patient costive for a week or ten days. For this reason, only fluids are given, and the patient is kept under small doses of opium. If, contrary to expectation, there are movements of the bowel, it is better to stop the administration of opium and clear out the intestines with a good dose of castor oil, after which the opium treatment may be resumed.

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[1] See also Vol. IV, Chaps. VIII and XI.

Operation for Hemorrhoids, Fissure in Ano, Etc.—In some clinics, following operations for hemorrhoids or anal fissure, a "whistle"—a cannula consisting of a $3/8$-in. rubber tube around which some gauze (iodoform or plain, coated with vaselin) is rolled—is inserted into the anus and kept there for 4 days (until the bowels are moved for the first time). Those who use it state that it gives early warning in case of hemorrhage above the sphincter, keeps the sphincter ani well dilated (the dilatation of the sphincter is one of the most important elements of the treatment of hemorrhoids or fissure in ano), and allows the uninterrupted passage of flatus. Others oppose the use of the "whistle," maintaining that it causes unnecessary pain, presses against the prostate and urethra, favoring retention of urine, and is not needed if the operation and digital stretching of the sphincter have been properly done.

It may be remarked that there is distinctly less pain after enucleation and suture of mucous membrane for hemorrhoids than after clamp and cautery operations.

The standard method for treating these cases is to keep them constipated for 4 days (fluid diet, opium), then to inject several ounces of oil into the rectum (through the cannula if one has been used), to soften the feces, and to move the bowels with a good dose of salts. A sitz bath on this day and the following days often affords much relief. A flat piece of gauze anointed with boric acid ointment is all the dressing necessary. As a matter of course, the anal region is cleansed with soap and water after every movement.

HEMORRHAGE.—This may go on unnoticed for a long time if the sphincter is intact. Even if a cannula has been inserted in the sphincter, it is no absolute safeguard, for its lumen may be obstructed by a clot. Finally the rectal pouch becomes overdistended, and the bowel empties itself of a large amount of blood and clot. By this time there is a considerable grade of anemia present. The most frequent times for hemorrhage to occur are within the first 24 hours and after the first movement of the bowels.

The lesser degrees of hemorrhage are controlled by local applications of cold—ice-water irrigations and similar measures. More severe forms require exposure of the field (with or without narcosis) and control of the bleeding point. **A hemostatic suture is better than simple ligature, actual cautery, or tamponade.**

INFECTION.—If infection occurs after a suture operation, the stitches are removed, the wound is reopened, and, if necessary, incisions are made to provide for freer drainage. The employment of rubber tubes or of rubber tissue is just as satisfactory and they are much less painful to remove than gauze. The only time the latter may be employed is in the later stages of convalescence, to keep the cutaneous part of the wound open so that it may granulate from the bottom. If the discharges are profuse, Irish moss pads are very convenient.

In some cases a permanent bath is of the greatest service. The fact that the granulations lose their red color and become pale and grayish is of no consequence. As soon as the bath is discontinued, they may be brought back to their proper bright red color by the application of tincture of iodin, balsam of Peru, or the silver nitrate stick.

LATE POSTOPERATIVE CARE. Upon discharge from the hospital, the patient should be informed that the presence of small anal tabs is of no consequence. He should be warned against straining at stool and be instructed to regulate his diet so that there is a daily movement of the bowels; in case a movement does not occur, an enema is better than to wait another day or than to take a cathartic, as it disturbs the gut less. Bending over at stool is less of a strain upon the hemorrhoidal veins than the upright posture assumed by some. Should hemorrhoids prolapse, their replacement, followed by a prone position for 15 or 20 minutes, often tides matters over.

ANAL STRICTURE. Stricture of the anus is apt to follow improperly performed Whitehead operations, i. e., the wounds heal by granulation instead of by first intention, hence the large amount of scarring. The Whitehead operation for hemorrhoids has won undeserved ill repute as predisposing to the formation of stricture to a greater extent than other operations. The combined reports of Stone (12) and Lloyd (9) and Hadda (6) of about 900 late results show that if the operation is properly performed, it is not followed by stricture. It is well in any event to examine every case digitally before discharging it. In those in whom granulation has taken place, it is well to examine as soon as the granulations have formed well. The stricture will stretch more readily under bougieing during the period of granulation than afterward.

THE USE OF BOUGIES. There should be 2 or 3 sizes (a little smaller and a little larger than the diameter of the stricture). Plenty of lubricant should be used and the instrument introduced firmly but gently. The use of too much force must be avoided, as one cannot tell whether the resistance felt is by the stricture or by the ulcerated bowel wall beyond it. I know of a number of cases where the bowel has been perforated by bougies. The patients generally died in spite of immediate laparotomy and suture of the rent in the gut.

After introduction, the bougie should lie in place 10 to 15 minutes. When finally the proper degree of dilatation has been reached, by a course of daily séances, the bougie must be passed from time to time over a long period, to prevent recurrence. At first the intervals should be short (not more than a week or 2), later they can be lengthened out to a month, still later to 2 or 3 months. Finally the patient should present himself 2 or 3 times every year to make sure that no contracture has taken place.

When the stricture does not yield to the passage of bougies alone, it may prove amenable after multiple small incisions have been made. These are safer than 1 large cut, which may open up the perirectal cellular tissue or even the peritoneum.

In still more obstinate cases of rectal stricture, colostomy followed by resection of the diseased tract is the only means of attaining a cure. This type of marked stricture seems to be more frequent on the continent of Europe than in America. It is usually of a syphilitic nature and occurs most frequently in women, generally prostitutes. (Common among negro women.—EDITOR.)

INCONTINENCE.—If incontinence follows division of the sphincter at *operations for fistula*, control is usually regained in the course of time. If not, the scar must be excised and the sphincter repaired (see Postoperative Operations).

Operation for Prolapse of the Rectum.—Without doubt the most effective operation for this is the obliteration of the pouch of Douglas from above (Moschcowitz). The patients are kept in bed for 3 weeks before they are allowed to get up.

Operation for Carcinoma of the Rectum.—The type of operation for rectal carcinoma will depend upon the site of the growth and the degree of involvement. Thus, if the tumor lies within 1 or 2 in. of the anus, the anatomy of the lymphatics in this region demands that, besides the growth, the sphincter and the surrounding skin as well as the inguinal lymph-nodes should be extirpated. Whether a sacral or an abdominal anus is established must be determined by the operator for the individual case.

In carcinomata more highly seated, it is at times feasible to leave the sphincter and an inch or so of rectum intact, to draw down the bowel and establish a sacral colostomy and then later, a year or so after the original operation, to unite the 2 ends. Harrison Cripps, who has done this, states that by this time one is fairly sure regarding recurrence in the majority of cases. A primary union of the end-to-end type invariably leaks; it is no longer attempted.

Another way of dealing with conditions after resection of a tumor of the rectal ampulla is to bring down the end of the mobilized sigmoid and suture it so that an inch or so projects through the anal orifice. At operation the carcinomatous portion of the gut is removed in 1 piece, together with macroscopically healthy gut above and below, the latter including the mucous lining of the anus; the sphincter is split behind, and the mucosa is dissected from the sphincter muscle without opening the intestinal lumen. The gut above has been crushed and ligated, divided with a Paquelin cautery, invaginated in a strictly aseptic manner, and then brought down to the anus. So far, this method has not been uniformly successful—in a considerable percentage of cases, the mobilized gut has undergone more or less necrosis. Some surgeons ascribe this lack of viability to ligation of the mesenteric vessels, which, of necessity, must be divided to permit mobilization; the vascular anastomoses in this region are subject to considerable variation. Others maintain that, if there be no tension whatsoever, the gut will live even if the normal arterial supply is cut off. The question is still open.

Krogius does not try to mobilize the gut under these circumstances; instead he reaches up through the peritoneal cavity and pulls down the summit of the sigmoid loop, which is then sutured to the denuded sphincter ani. Others have found that unfortunately the sigmoid is not always long enough for this measure.

Lastly we come to the combined operation—the most rational method of all, because it permits of inspection of the liver for metastatic deposits as well as affording the operator an excellent exposure of the field from above. This leaves the patient with a left iliac colostomy (see page 118). If properly managed, it causes surprisingly little inconvenience—much less than a sacral or perineal colostomy (see Care of Colostomy, below).

In any event, resection of a carcinoma of the rectum is one of the gravest of major operations, the mortality in any but the most skilled hands being in the neighborhood of from 20 to 25 per cent.

The patients reach the ward in severe shock. Some gradually improve, others sink steadily. Transfusion at this critical time, especially if prepared for before operation, may save a considerable percentage of cases which do not respond to intravenous infusions of normal saline solution. For details of treatment for shock, see the preceding chapter.

PARESIS OF THE BLADDER.—Paresis of the bladder almost invariably follows extirpation of the rectum by the Kraske method. Catheterization must be practiced for a long time. Needless to say, the strictest asepsis must prevail to save the patient from a troublesome cystitis if nothing worse. The details of catheterization and the administration of urotropin have been dealt with in the preceding chapter. In the course of a few weeks the paresis gradually disappears.

If the peritoneum has been soiled at operation or if a leak forms afterward, the outcome is usually fatal. If the leak occurs outside of the peritoneum and there is adequate drainage, survival after a few days of fever is the rule. It is better to remove the stitches from the perineal wound rather than to risk retention.

RECURRENCE.—From time to time the patient should present himself for examination. Search should be made for local as well as for distant deposits. Cases have been known to remain permanently cured after repeated extirpation of local recurrences.

INOPERABLE CASES OF CARCINOMA OF THE RECTUM

Palliative colostomy for inoperable stenosis of the rectum is often followed by as marked an improvement (for the time being) as that observed after radical operation.

The pain from involvement of the sacral plexus soon proves uncontrollable by even the largest doses of morphin. Division of the anterolateral columns of the spinal cord gives permanent relief.

In ascites from diffuse abdominal carcinosis, repeated tappings are the only means of disposing of the fluid. None of the host of operations devised for this purpose have proven of the slightest practical value.

Involvement of the bladder is to be treated symptomatically.

Colostomy.[1]—Where the intestine has simply been delivered upon the abdominal wall and has been fixed in this position, the actual opening is made in the ward a day or 2 later. It is done with a Paquelin cautery. If any arteries are opened, they are ligated.

If a spur has been formed it is well not only to empty the upper loop from time to time, but also to irrigate the lower loop periodically to avoid stagnation of secretions.

Prolapse of the gut is controlled by application of a suitable pad. If through neglect an irreducible prolapse has occurred, the cicatricial neck of the ring of the colostomy wound can be carefully divided under local anesthesia and the gut replaced.

The care of a permanent colostomy is so well described in an article by W. W. Keen (8) that I quote it here in part.

METHOD OF DRESSING INGUINAL ANUS

Speaking of his patient, Keen says: "As he has had so long and so successful an experience (20 years) in dressing the inguinal anus and in observing the condition of the culdesac from the open inguinal anus to the closed perineal anus, I quote in detail his method of dressing the inguinal anus. This is always a problem of serious import to the patient. Many devices, often cumbrous and costly, have been used. The patient's method is so simple and so effective that I believe a detailed description—for even the little details are important—will be welcomed both by the surgeon and his patient.

"The illustrations accompanying the article well illustrate his present condition. His suggestion of a 'dummy' truss has been of great value to other patients after a similar operation. The truss, as he says, is the 'key to the situation.'"

Keen goes on to quote his patient as follows: "'The bowel ends protrude, normally, about half an inch outside the wall of the abdomen (Fig. 14A). The end of the unused bowel (the blind lower segment) does not vary in size; it is inert. The end of the active bowel is like it when conditions are normal. . . . I have fairly regular movements every morning, depending, of course, somewhat on regular habits of eating and drinking, which also affect the character of the discharges as to their being formed or semi-liquid. . . . My motions are never under control as with a normal sphincter. At the same time they give me fair warning. If formed they do not hurry me and in cases of necessity, as when traveling, I can carry a movement for hours. But if semi-liquid or worse they must be cared for promptly.

"'Now, as to protection (Figs. 14B and C): You are right in wanting this in detail, for it is that which must take the place of control, and it is the key to the situation. I am sending you under separate cover a T-bandage and pads of absorbent cotton which have served me so well all these years. I have seen expensive surgical appliances of

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[1] See also Vol. IV, Chaps. VIII and XI.

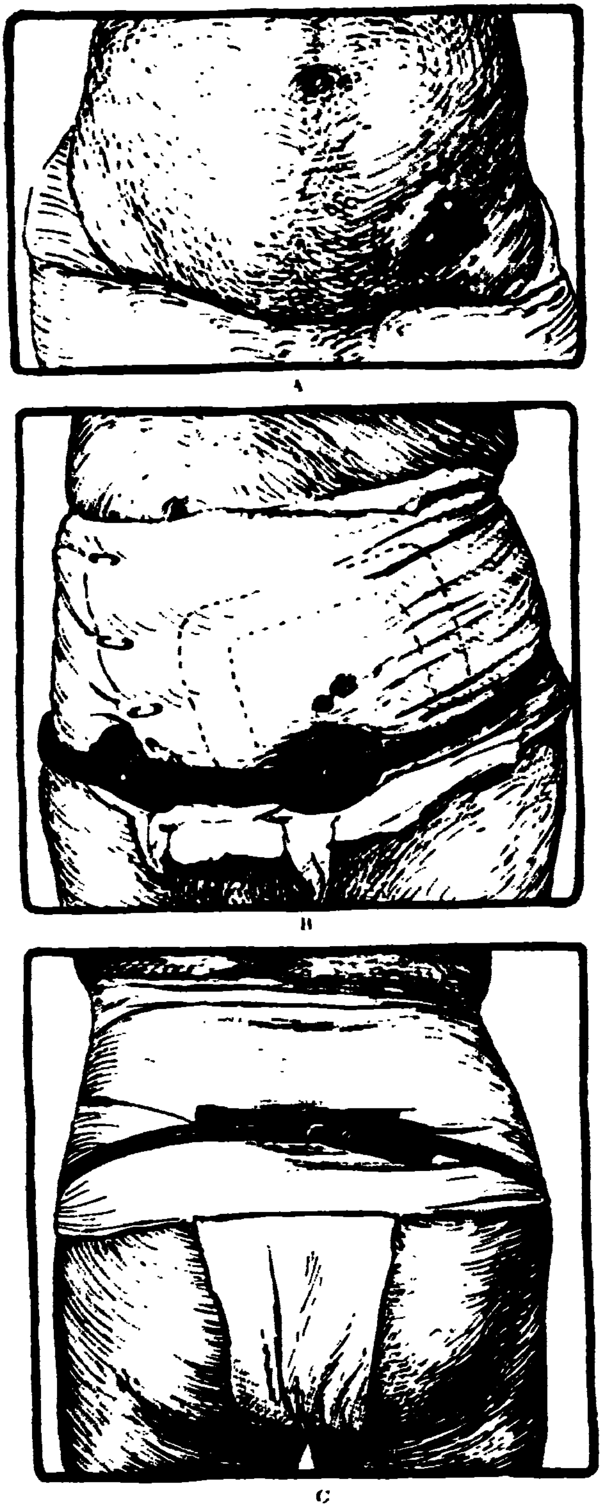

FIG. 14.—INGUINAL ANUS. A, Inguinal anus. B, Front view with dressing in place. C, Rear view. Details in text. (After Keen.)

silver cup, rubber tube, and reservoir which were of no use at all. Lying on my back with the bandage spread out under me, I first wrap a string of absorbent cotton around the bowel ends. Then I place over the abdomen a layer of cotton about 8 by 11 inches, reinforcing it at the bottom with another strip 3 inches wide to make double thickness. This is better to support the flange at the truss and to increase absorption. Over this pad I lay a smaller piece of cotton or linen cloth—any clean old rags will do—then another sheet of cotton, split thin, then another cotton rag and on this a square about 5 by 6 inches of rubber cloth. These cotton pads extend one-third of their length over the bowel ends to the right and two-thirds of the left and down the side, as it is in the latter direction that the movements spread most.

"'Then I bring the bandage over from the right side, lap it with the end from the left side and fasten with five safety-pins 1¼ inches long, beginning at the bottom and drawing fairly tight. I then bring up the split ends of the T and fasten each end to the lower edge at the encircling bandage. The bandage should not cover the lower edge of the pads by half an inch. This is a good deal of detail, but it is all-important. The cloth square between the pads catches the moisture which goes through the cotton, and the one under the rubber will be wet while the cotton under it is dry. The rubber protects the bandage when the discharge is profuse. In dressing a movement, I simply fold back the cotton not soiled and gather off the feces with a square of soft paper, cleanse with part of the cotton pad and redress with new as may be necessary.

"'Next, standing, I adjust my truss; and let me say here that a truss is an absolute necessity. It is the only insurance against disastrous leakage down into the clothing of liquid feces. It constricts the lower edge of the bandage, holding it tight to the groin and making the bandage and pads a safe reservoir even with liquid discharges, if they are not too profuse. Of course, if they are profuse all pads will be saturated, and sometimes there will be leakage. But it must be a bad discharge that gets so far. You will find a slit in the middle of the wide bandage. This is to catch the edge of the back flanges of the truss and prevent the truss from slipping down—another important detail. The bandage I send you is made up as I use it. Open it carefully. The patient must keep a few on hand. It is made of 40-inch brown muslin. The strip half as wide as the bandage makes two T's.

"'The culdesac, which you perhaps considered an experiment, has served its purpose in preventing prolapse of the bowel, leakage of mucus and pain in the surrounding muscular tissue. The discharge from it at the open end is negligible. Once in a great while I find a thimbleful of gray matter, soft and odorless, on the pad. Once I thought there must be some accumulation of it and I tried to void it by hanging down, head to the floor from the foot-rail of my bed and manipulating the posterior end with my hands, but with no result; so I ceased to bother about it. It gives me no pain except sometimes it swells when I strain my abdominal muscles to effect a movement.'"

THE SPINAL CORD[1]

General Considerations.—One secret of success in all spinal cord operations is the obtaining of primary union. Under no circumstances should drainage be attempted. It almost invariably leads to infection.

The care of paraplegics, including prevention of bedsores, retention of urine, etc., has been discussed in the preceding chapter.

According to Elsberg, marked and persistent abdominal distention is espe-

[1] See also Operations on the Brain, Vol. II, Chap. XI.

cially apt to follow injury to the lower thoracic segments of the cord. Although the patients look extremely sick, he has never seen one die from this cause. After 3 or 4 days there is a spontaneous remission. Pituitrin may be of value.

At times a paradox diarrhea may be present; that is, a diarrhea due to irritation of the large intestine from retained fecal material. A thorough evacuation of the colon will usually put a stop to it.

The return of nerve function after injury to the spinal cord is usually followed by tearing pains and involuntary twitchings in the paralyzed limbs. Sensation returns before motor function. There may be pains but no return of function in some cases. Massage, electricity, and passive motion maintain nutrition of the paralyzed limbs (the charges for administration of electricity for this purpose are often disproportionate to the benefit derived) and prevent the joints from becoming stiff. The time of recovery varies with the character and extent of the injury. After simple exploratory laminectomy there may be edema from bruising of the cord at operation, giving rise to temporary paralysis varying from a simple girdle zone of anesthesia, passing away in a few days, to complete paraplegia, lasting for several weeks. As soon as the patient has regained a certain amount of voluntary motion, it is desirable to get him on his feet. This often leads to great improvement in general condition.

An almost indefinite number of laminæ may be removed, provided the vertebral bodies and transverse processes with their articular facets are uninjured. As soon as the skin is healed, no further dressing or support of any kind is required. **After operation for fracture the spine must be suitably supported by a corset, or corset and jury mast, depending on the locality of operation.** See Vol. I, Chap. XVII.

Fractured Vertebræ. Fractured vertebræ take a long time to acquire a firm, bony union, usually 3 to 4 months. It is, therefore, of the greatest importance to maintain the fragments in their proper position during this time, because if this is not done, as the broken body of the vertebræ undergoes more or less absorption, a kyphosis results. Before the days of the X-ray it was not unusual to observe, after relatively slight trauma to the back, apparently only a contusion, that, while the patients were able to follow their usual occupations for a time, later they began to complain of pain at the site of previous injury, and that the affected portion of the spine was held rigidly and was involuntarily protected from the slightest strain or shock. Examination at this time revealed nothing except local pain, but gradually, in the course of a month or so, a kyphosis developed and the pains gradually subsided as firm, bony union took place.

Nowadays, with the aid of the X-ray, we are able to treat such fractures more intelligently. (For splints and plaster jackets, see Vol. II, Chap. III.)

As to prognosis, it is generally considered that, if compression has not been relieved within 8 hours, permanent damage to the cord will result.

Spina Bifida.—It is especially important to provide against infection in this region because of its proximity to the anus. Laying the patient on the side and the use of collodion uniting the dressing to the skin on the side toward the anus may do a great deal toward preventing infection from soiling of the wound and its dressings with fæces.

Leakage of cerebrospinal fluid in this locality is very apt to be followed by meningitis. Paralyses may be a result of congenital deficiency in the development of the nerves or to injury at operation. The former exists before operation, the latter appears immediately afterward. Close observation will frequently reveal signs of slight hydrocephalus before operation in many of the children with spina bifida. It is, therefore, not surprising to read of the frequency with which hydrocephalus is observed after operations for spina bifida.

THE GENITO-URINARY TRACT[1]

Urotropin.—Urotropin (hexamethylenamin) is a mild urinary antiseptic; it has the property of breaking down and liberating formalin in fluids having an acid reaction. In alkaline fluids it is inert and exerts no bactericidal effect. After administration, it is found in the blood, in the alkaline cerebrospinal, pleural, pericardial, and synovial fluids, also in the bile; but, as just said, it can have no bactericidal effect in these fluids because of their reaction. The whole subject has been well epitomized by Hanzlik and Collins (7).

For this very reason, before administering hexamethylenamin, it is essential to ascertain the reaction of the urine—if it is alkaline, it must be made acid before any effect from the drug can be expected. The following drugs are useful for producing acidity of the urine: benzoate of soda, 10 to 20 gr.; sodium acid phosphate, 20 to 30 gr.; benzoic acid, up to 30 gr. Any one of these is to be given 3 times a day. Boric acid has been used for the same purpose.

The customary dose is 7½ gr. 5 times a day. The urine should be watched for the appearance of red blood-cells. As soon as these are noted, the urotropin should be stopped for 3 or 4 days.

THE KIDNEY

Nephrectomy.—KIDNEY FUNCTION.—The proper functionating of the remaining kidney after nephrectomy is of prime importance to the surgeon and of vital moment to the patient. In certain cases, in spite of the diagnostic means at our disposal (see Vol. IV, Chap. XII), it may be rather difficult to tell whether the kidney which is to be left behind possesses adequate functional capacity. Clinical experience has shown that the presence of a diseased kidney on one side may have a strong inhibitory influence upon the opposite kidney

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[1] See also Vol. IV, Chaps. XII and XIII.

(which subsequent events prove to be, to all intents and purposes, healthy), so that it gives extremely low functional tests before operation. Again, the presence of a diseased kidney on one side may give rise to a toxic nephritis of the other, comparatively healthy kidney. This clears up within a few days after operation. Lastly, the opposite kidney may actually be incompetent (it may be so diseased that only an extremely small amount of functionating kidney tissue is left). The X-ray may prove of the greatest value in arriving at a decision. In 90 per cent. of cases the plates made by a competent röntgenologist reveal the outlines of the kidney.

The determination of incoagulable nitrogen in the blood seems to promise additional aid in determining kidney function before operation.

For the diagnosis of kidney function the reader is referred to the textbooks upon this subject. As good a one as any, perhaps, is "Nierenphysiologie und Nierendiagnostik" by V. Blum (1). Also Chap. XII, Vol. IV.

After nephrectomy oliguria during the first week and polyuria later are the rule. Persistence of pus or blood in the urine indicates the use of the cystoscope and the ureteral catheter to ascertain the origin of trouble. If the ureter on the diseased side has been left in, this may be the source of the purulent discharge. Even a short stump of diseased ureter (where most of it has been removed) may cause this condition.

H. Wildbolz (15) states that after nephrectomy there is marked sensitiveness to atropin and medinal.

At times the reflex anuria observed before operation continues afterward, and the symptoms of uremia may gradually develop.

TREATMENT OF UREMIA. A Murphy drip of *plain* water (2 hours on and 2 hours off) should be given. Hot colon irrigations (110° F.) twice a day and hot packs (110° F.) at suitable intervals should be administered. Hot packs are simpler to administer than hot baths. The patient should be encouraged to drink plenty of hot water.

MEDICATION. If the indications are urgent, a pint of 5 per cent. glucose in freshly distilled sterile water should be given intravenously. The glucose solution serves a double purpose: (1) It may be safely injected into the bloodstream (5 per cent.—more accurately 4.8 per cent. glucose is isotonic with 0.85 per cent. normal saline) as a means of introducing fluid without salt; (2) large amounts of carbohydrate depress nitrogen metabolism, and in that way serve to delay the accumulation of nitrogen waste products. Under less urgent indications, the glucose may be given subcutaneously, 10 to 16 oz. 3 times a day; and under still less urgent conditions, the same condition may be given by proctoclysis.

Drugs are not very much used. Of these, diuretin (theobromin-sodium salicylate), 15 gr. every 4 hours, has been recommended; ariston (a caffein-sodium-benzoate 0.25 per cent.) is used by Bentley Squier.

For convulsions, various sedatives, chief among which are chloral and bromids, are indicated. Opiates must not be used because of their inhibitory effect upon the kidney.

PHLEBOTOMY.—If the diagnosis of uremia is certain, and if the pre-operative functional and blood-tests show marked retention of nitrogen waste products, phlebotomy is positively indicated, except when the pulse pressure is too low. If there is not much anemia, 10 to 16 oz. may be drawn off. The anemia of nephritis is more apparent than real. The object of the phlebotomy is to relieve the body of a certain amount of poisonous material contained in the blood withdrawn; remember that not only is the blood saturated with these noxious waste products, but all the tissues are impregnated with them. The withdrawal of blood and the administration of fluid serve to lessen concentration.

DECAPSULATION.—The entire subject of nephritis is undergoing extensive modification at the present time; naturally this gives one a rather unstable footing. Clinically, 2 forms of nephritis can be differentiated, the parenchymatous and the chronic interstitial.

Parenchymatous nephritis is caused by an acute intoxication (either bacterial or chemical). The urine is small in amount, with a high specific gravity, and contains much albumin and a large number of casts. The blood-pressure is not necessarily high. The acute swelling of such a kidney (with suppression of urine) is relieved by decapsulation. This operation has only a temporary effect; the nephritis may subside for the time being to recur within a few months.

(While decapsulation gives temporary relief, it is followed by deposits of a large amount of fresh cicatricial tissue around the kidney, which, within a year or 2, undergoes the customary cicatricial contraction, leaving the kidney worse off than it originally was.)

Chronic interstitial nephritis is part and parcel of a general arteriosclerosis.[1] There are polyuria, low specific gravity, little albumin, few casts, low chlorid and low nitrogen elimination. There is high blood-pressure. Naturally, decapsulation of a kidney in which there is so much fibrous tissue will not relieve suppression.

DIET.—The diet in nephritis should be high in carbohydrates and fats, and low in protein material (no meat, no eggs). In the chronic interstitial form the salt-free diet is of more benefit than in the parenchymatous form. For keeping the bowels open, Glauber's salt is preferable to Epsom salts—the former reduces the acidity of the urine, the latter raises it.

TREATMENT OF THE WOUND.—As a rule, all cases of nephrectomy are drained and their postoperative treatment is no different from any other deeply drained wound. The proper method for *removal of clamps* is described under Control of Hemorrhage in the preceding chapter.

In some cases of pyonephrosis it is impossible to ligate the vessels and the ureter separately because of infiltration at the hilum. Under such circumstances, an *elastic ligature* is thrown around the pedicle, the silk ligature which binds the crossed limbs of the elastic ligature being led out upon the skin. Under no circumstances should this be pulled upon until the third or fourth week after operation. As a rule, the ligature comes away of itself.

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[1] Chronic interstitial nephritis may be secondary to an acute parenchymatous nephritis.

If a tuberculous pyonephrosis is not removed intact, the walls of the kidney sinus often become infected, converting it into a *tuberculous sinus*, which is very difficult to close. If the kidney is removed and the diseased ureter is left behind, the latter may be responsible for persistence of the lumbar sinus. Frequently the diseased ureter also gives rise to persistent pyuria.

By certain surgeons, it has been suggested to make a *primary closure* after nephrectomy combined with ureterectomy for tuberculosis of the kidney and ureter. I know of at least 10 cases in which the kidney wound re-opened 10 or 12 days after an apparently perfectly aseptic operation. The iliac wound through which the lower part of the ureter was removed never re-opened. The kidney wound then healed by granulation.

In the course of difficult right-sided nephrectomies, the duodenum is occasionally injured and a *duodenal fistula* develops. For control of this complication see High Intestinal Fistulæ, page 109.

Nephrotomy.—HEMATURIA. After nephrotomy there is more or less hematuria which subsides within a few days. Secondary hematuria (hemorrhage) usually comes on at the beginning of the second week. The patient may lose so much blood by way of his urinary passages that a secondary nephrectomy becomes imperative. The chances for success are greatly increased by preliminary transfusion just before operating.

At a meeting of the American Surgical Association several years ago, in which the subject of secondary hemorrhage after nephrotomy was discussed, A. G. Gerster pointed out that the hemorrhage usually came on sometime during the second week, that is, at the time when secondary hemorrhage is to be expected in septic wounds—the thrombi occluding the mouths of vessels becoming liquefied and readily displaced. A. G. Gerster pointed out the advantage in nephrotomy for stones, for example, of locating the stone with a needle or a probe and then bluntly boring through the kidney substance with a dressing forceps, instead of splitting it with a sharp knife. By blunt separation it is possible to avoid injury of the larger vascular elements of the kidney, and experience has shown that secondary hemorrhage is less apt to follow it.

When the stone lies in the pelvis of the kidney (in 90 per cent. of X-rays, the outlines of the kidney are so distinct that it is possible to exactly localize the site of the stone, whether it is in the kidney substance or in the pelvis), it is unnecessary to touch the kidney substance. The pelvic wall is divided and the stone extracted through this wound.

SECONDARY NEPHRECTOMY.—After simple drainage, persistence of fever may be due to infection of the opposite side, to cystitis, or the presence of multiple foci of infection in the drained kidney which have not been reached. Do not wait more than a week or 10 days after primary nephrotomy before doing *secondary nephrectomy*. By this time the patient has recovered from the previous operation. It is improbable that he will improve much more with an improperly drained focus of suppuration, that is, he is as strong now as he ever will be unless relieved by operation. Technically the shelling out of the diseased kidney is easier at this time than later, when the connective tissue deposit around it is firmer.

The drainage tube from a nephrotomized kidney should be removed only after the wound secretions have been clear for some time.

URINARY FISTULÆ.—The Mayos have demonstrated that reinforcing the suture line with a fatty fascial flap after pyelotomy and using rubber tissue instead of gauze for drainage is the most satisfactory method to follow in avoiding the production of a urinary fistula.

The closure of a urinary fistula after nephrotomy may be prevented by a ureteral obstruction. The patency of the ureter may be demonstrated by insertion of a ureteral catheter under guidance of the cystoscope and injection of colored fluid, which will be seen escaping from the lumbar wound. Before resorting to any plastic operation for closure of the lumbar wound a ureteral catheter should be inserted up to the kidney pelvis and left in situ for 24 hours.[1] Von Hacker's method for closure of fistula is suitable for narrow openings.

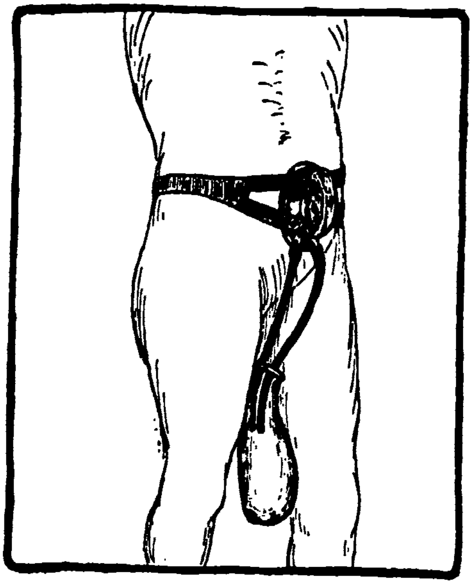

FIG. 15.—URINAL FOR PATIENT WITH SUPRAPUBIC FISTULA. (After Pilcher.)

The treatment of a urinary fistula, whether in the lumbar, inguinal, or suprapubic region, is the same. For the first few days, while the deep drainage and packings are in place, the superficial dressings should be frequently changed. Irish moss pads are particularly useful for this purpose. As soon as it is feasible, a suitable urinal should be fitted to the opening and should be made adherent to the skin by means of rubber dam and rubber cement (Fig. 15). If this is not feasible, the skin should be protected by a liberal application of bland ointment. Sitz baths are also good.

URETERAL STONE.—In closing the ureter after extraction of a stone, if the wound in the ureter is accessible, it is closed by a few catgut stitches and a generous supply of rubber tissue is used as a drain. If, on the other hand, the wound is inaccessible, or if it is so located that suturing would be tedious and difficult, no attempt is made to close it, but it is surrounded by a rubber dam and the superficial wound is partly closed by a few stitches at either angle. There is leakage of urine for a few days followed by spontaneous cessation. As said elsewhere, the use of gauze as drainage material down to a suture line is a vicious practice. The pulling away of the gauze breaks up the fine granulations closing the sutured region and produces leakage instead of preventing it.

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[1] This may give the granulations just time enough to effect a closure.

In certain cases the ureter is cut down upon for stone, opened, and no stone is found. Such a contingency might have been avoided by the use of proper diagnostic means. The insertion of a catheter with a metal core into a ureter and the coincidence of its shadow with the shadow of the supposed ureteral calculus does not prove the presence of the latter. The shadow may be due to a phlebolith or a calcified lymph node or some foreign body in the gut. On the other hand, injection of the ureter with silver salts under the X ray invariably shows dilatation of the ureter down to the point where the ureteral calculus lies.

The discovery of a ureteral stone does not indicate immediate operation (see Vol. IV, Chap. XII).

Drainage for Hydronephrosis. If a hydronephrosis has been drained and the opening persists, it is possible that the original cause of the hydronephrosis has not been removed. Before proceeding to a secondary nephrectomy, the opposite side should be examined.

In testing for hydronephrosis, injection of the ureter with indigocarmin is less irritating than with silver salt. Through the cystoscope one watches for the reflux of the colored fluid. The amount injected being known, one can thereby determine the capacity of the ureter and the renal pelvis. If this is far beyond the normal, hydronephrosis or dilatation of the ureter may be suspected.

Nephropexy. The patients should keep their beds for at least 3 weeks, during which time a course of forced feeding should be given. A movable kidney is often merely part of a general visceroptosis; 20 per cent. of all women have movable right kidneys which give no symptoms (Mayo Clinic).

The lack of success of this operation (i. e. failure to afford relief) is due to poorly established indications for performing it.

THE BLADDER[1]

General Considerations. The chief mortality in this class of operation is due to failure of the kidney after operation. Prevention lies in the preliminary examination and treatment. The entire urinary tract should be examined by the X-ray (stone). If there is residual urine this should gradually be decreased by frequent catheterization (3 to 4 times a day) extending over a week or so until it has been reduced to nil, then a permanent catheter should be inserted and worn 2 to 3 days. **Do not operate until the phenolsulphonephthalein output reaches something over 10 to 15 per cent. in two hours' excretion.**[2]

A preliminary transfusion in anemic or debilitated patients is a great aid in helping them to withstand operative shock.

[1] See also Vol. IV, Chap. XIV.

[2] Those cases with very low secretion—some with 0 per cent. excretion—even if they survive operation usually die within a few months.

Lastly, the shorter time they are on the operating table, the better is their chance for recovery, all things being considered.

After any bladder operation when the patient is suffering much pain and one is sure that the bladder is empty, the patient can frequently be relieved by injection of 2 or 3 oz. of a sterile boric acid solution, thus raising the top of the bladder away from the trigone.

Treatment of Cystitis.—Cystitis, if present, should be subjected to a thorough course of treatment before proceeding to any major operation. The patient is given plenty of water to drink. In addition to urotropin, he should receive medication for rendering the urine acid, in case it is alkaline. Tincture of hyoscyamus, minims 30, every 3 to 4 hours, should be given for the relief of tenesmus, also deodorized tincture of opium (♏ x, 3 times a day) if there is no nephritis.

CATHETERIZATION.—During the acute stage the bladder is emptied and thoroughly irrigated 3 to 4 times a day by catheter. Whereas with the patient standing erect the lowest point of the bladder is at the trigone and, therefore, emptying is most complete in this position, certain individuals have a tendency to become faint if they stand while having their bladder washed out, and it is, therefore, safer to have them lie flat on their backs. The anterior urethra should be irrigated thoroughly with boric acid solution or oxycyanid of mercury, 1 : 5,000, and the meatus should be wiped off with a swab soaked in 1 : 2,000 bichlorid. The sterile catheter should be laid upon a sterile towel, and no part of the catheter which is to enter the urethra should be touched by the hands, unless the latter are also sterile. (It is safer to wear a pair of sterile gloves than to trust to the asepsis of one's skin.) If gloves are worn, be sure that the (right) hand which is to pass the catheter does not become infected. The well-lubricated catheter should be inserted with the utmost gentleness. The opposition offered by the sphincter should be overcome by gentle, constant pressure.

In hypersensitive individuals 10 to 20 c. c. of a 2 per cent. novocain solution may be injected into the urethra and bladder preceding catheterization.

Rubber, metal, and glass catheters are boiled before being used. Woven catheters do not stand boiling; after being used, they should be washed in soap and water, dried, and then hung up in jars, at the bottom of which are formalin pills.

IRRIGATION.—After the bladder has been emptied, an irrigating solution is injected. If an irrigator is used, it should not be higher than 1½ ft. above the patient's head. Some surgeons prefer to irrigate with a hand syringe (the usual syringe having about 300 c. c. or 8 oz. capacity), stating that this gives them a better control. Never inject more than 150 to 300 c. c., the exact amount to be determined by the patient's sensation; as soon as there is a sensation of fullness, filling is stopped and the bladder is allowed to empty itself. From time to time, the return water should be caught in a specimen glass in order to see whether it is becoming clearer.

Some men employ a T or a Y connection with 2 cocks, the side opening being closed while the bladder is being filled and the inlet from the irrigator being closed while the bladder is being emptied. Others employ the Hegar glass funnel of 300 c. c. capacity, having a rubber tube 1 meter long, connected to the catheter. The bladder is washed out by alternately raising and lowering the funnel.

When the return is finally clear, the bladder is filled with a suitable antiseptic solution for from 5 to 10 minutes. Potassium permanganate, oxycyanid of mercury, and silver nitrate are the favorite substances. The permanganate used is a good red wine color (about 1 : 5,000), oxycyanid of mercury in 1 : 5,000 solution, and silver nitrate either as irrigation in the form of 1 : 1,000 solution or, in the later stages, as instillation (5 to 10 drops of a 2 to 3 per cent. solution). After this, the bladder is washed out again. The catheter should be withdrawn slowly with the irrigation flowing so as to irrigate the urethra as it comes out.

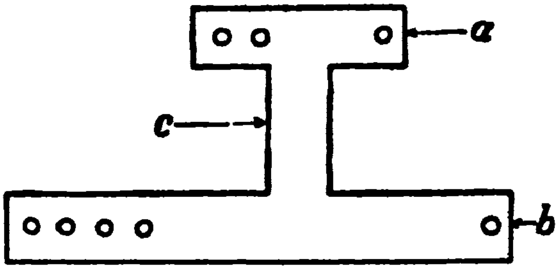

FIG. 16. A DOUBLE T OF RUBBER DAM FOR HOLDING A PERMANENT CATHETER IN PLACE. Holes are punched into the horizontal arms of the "T"; small sized bone or glass collar buttons are best for fastenings. The smaller arm *a* tightly encircles the catheter just as it emerges from the urethra. The longer arm *b* encircles the penis immediately behind the corona glandis. The connecting arm *c* is placed posteriorly covering the frenum.

Warm sitz baths and hot packs also afford the patient a great deal of relief.

In very bad cases of cystitis, it is preferable to establish suprapubic or perineal drainage rather than to employ a permanent catheter. Under such circumstances, if the latter is used, it may give rise to an orchitis, or to decubitus of the neck of the bladder or the urethra, which will cause stricture later on.

PERMANENT CATHETER. A permanent catheter may conveniently be held in place by suitable strips of adhesive plaster, or by using a T shaped rubber contrivance made of rubber dam with collar buttons in the holes (Fig. 16). It is more comfortable to plug up the catheter and to allow the bladder to be nearly emptied every 3 or 4 hours, than to allow a constant escape of urine. The presence of an ounce or 2 of fluid in the bladder keeps the top of the bladder from pressing down upon the catheter projecting through the trigone and from causing pain by this pressure. The permanent catheter should be changed once every 4 or 5 days, to avoid incrustations. If there is any doubt as to its patency, the question can be cleared up by the injection of a little fluid into the bladder.

In the presence of peri-urethral infection, it is better to establish suprapubic drainage than to employ a permanent catheter.

Suprapubic Prostatectomy.[1]—While primary suture of the bladder after

[1] See also Vol. IV, Chap. XIV.

suprapubic prostatectomy is an ideal procedure, it is risky. A number of operators report having to re-open the bladder for hemorrhage or the removal of large clots. Primary suture must never be performed in the presence of cystitis. Hemorrhage is controlled by packing down on the mucous membrane overlying the empty bed of the prostate, the end of the gauze strip being led out through the suprapubic wound.

The 2-stage operation is the method of choice with most operators. After the preliminary opening in a 2-stage prostatectomy, the difficulty of urination may entirely subside so that the patient is unwilling to undergo the second stage of the operation.

Within 3 or 4 days after operation, the large tube is exchanged for a smaller one, which is inserted within it before the larger one is withdrawn. This insures proper position of the smaller tube and causes the patient much less pain than withdrawal and subsequent insertion. The suprapubic fistula closes more quickly if the opening in the bladder has been made as high up as possible, so that urine does not escape until several ounces have collected in the bladder. As the fistula narrows, the patient begins to pass urine by the urethra, and as the amount escaping in front diminishes, the amount naturally passed increases. A permanent catheter hastens closure of the fistula. The use of a urinal applied to the skin around the suprapubic fistula has been referred to above.

It is important to watch the kidney function of the patients. Their fluids should be forced, and they should receive 7½ gr. of urotropin 5 times a day. At least 1,500 c. c. of urine should be passed per day. Often it is impossible to tell exactly how much has been passed, because so much escapes into the dressing. Under these circumstances the patient's tongue is an excellent guide; if it is moist, the patient is getting enough fluid; if it is dry, fluid should be forced (see Treatment of Uremia).

Proper preliminary treatment (gradual diminution of the residual urine, etc.) is the best method for preventing anuria.

LATE RESULTS AFTER SUPRAPUBIC PROSTATECTOMY.—There may be a slight amount of residual urine due to atony of the bladder. Incontinence usually indicates that the operator has gone too far down in the urethra when shelling out the prostate, and has injured the sphincter of the bladder. As to sexual potency, if the operation is properly done, it remains about the same as before. In other words, if it has been present before operation, it usually is present after. If it has been absent before operation, it is not as a rule regained. Frequency of urination may last for months—it is the last symptom to disappear.

Perineal Prostatectomy.—See Vol. IV, Chap. XIV.

Treatment of Stone.—If a stone is present and there is no cystitis or enlargement of the prostate, it may be possible to crush it (litholapaxy). If, on the other hand, a cystitis or an enlarged prostate is present, the latter condition should be treated regardless of the stone, which should be removed incidentally when the bladder is opened in the course of events. If the stone is too large for crushing and there is no cystitis or enlarged prostate, primary closure of the bladder may be performed after its removal.

After litholapaxy the urine for the first day or two often contains fine sand and some blood. There may be a burning sensation in the urethra. Always examine with a cystoscope to make sure that no fragments have been left behind.

After *suprapubic cystotomy for stone*, in the absence of infection, a primary closure of the bladder may be made. If the patient is able to void spontaneously, it is unnecessary to insert a permanent catheter. In the presence of infection the bladder wound must be left open and allowed to close by secondary intention.

After any operation for stone the patient should be instructed to undergo a prolonged course of active exercise combined with the drinking of plenty of fluid to prevent re-formation of calculi.

Resection of the Bladder for Tumor.[1] What has been said about preliminary treatment need not be repeated here. In the presence of a tumor, do not empty the bladder completely, because this causes bleeding.

After operation, if hemorrhage is not controlled by hot saline irrigation plus complete emptying of the bladder, it may be necessary to re-open the wound and pack. The fulguration treatment for bladder tumors is given in the special section on this subject.

Certain surgeons believe that implantation of the ureters into the bladder results in hydronephrosis with extinction of kidney function within 3 years after operation.

Operation for Exstrophy of the Bladder.[2] Any operation for this condition consists in plastic work upon infected tissue. There may be retention necessitating re-opening of the wound. There may be marginal necrosis of flaps, or cutting through the stitches. The most scrupulous and frequent cleansing may not prevent the occurrence of eczema. A urinal must be worn because of the incontinence, which is almost never cured. Of the various operations devised for this condition, Sonnenburg's implantation of the ureters into the urethra seems to be the most sensible (providing a urethra exists).

Transplantation of the trigone or the ureters into the gut or into the skin of the back gives rise, within a few months, if not sooner, to an ascending infection and a fatal pyelonephritis.

THE URETHRA

External Urethrotomy.[3] As a rule, a permanent catheter is not necessary. In the presence of cystitis, however, the permanent catheter may be used and may be brought out through the perineal wound. Retrograde sounding is rarely necessary. In cases where this is specially indicated, the inner end of a permanent sound left in the urethra may be brought out through a suprapubic wound. This facilitates the drawing through of a second instrument, when the proper time comes, by attaching the latter to the end of the former. Systematic sounding must be kept up for months and years following either internal or external urethrotomy to prevent the recurrence of stricture.

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[1] See also Vol. IV, Chap. XIV.

[2] *Ibid.*

[3] See also Vol. V, Chap. III.

(This is by no means true of all cases. Many are cured by operation.—Editor.)

THE PENIS[1]

Phimosis Operations.—After circumcision in infants, all that is necessary is a liberal application of sterile boric acid ointment on a piece of gauze, to be renewed after each urination. If there is any infection, multiple incisions should promptly be made to relieve tension, because the skin in this region is particularly apt to undergo necrosis in young children (it is not uncommon to see the skin of the scrotum slough away after an erysipelas, leaving the testes exposed).

Hemorrhage may occur from the artery of the frenum. It usually leads to subcutaneous infiltration. The wound should be re-opened and the artery tied; it is better not to close it for fear of possible infection; rather pack it lightly with a bit of gauze.

In adults, one must guard against erections by forbidding alcohol or highly spiced foods; the bowels must be kept open; the patients should sleep upon their sides, not on their backs, and should be given sedatives. An ice-cold sitz bath is excellent in case danger threatens.

After circumcision in adults a convenient way of protecting the wound is to leave the ends of the interrupted sutures long, and, by means of these, to tie a small roll of gauze directly over the incision. If the prepuce has simply been split, subsequent small plastics improve the cosmetic effect by reducing the size of the redundant flaps.

Amputation of the Penis.—Hemorrhage from the stumps of the corpora cavernosa may not yield to compression. Coagulin-fonio or thrombokinase should be tried before resorting to hemostatic suture.

RECURRENCE OF TUMOR AFTER AMPUTATION.—If the inguinal glands have not been removed at the time of operation for tumor (usually carcinoma), they become the seat of rapidly growing secondary deposits within a few weeks.

PREVENTION OF ECZEMA.—If the stump of the penis lies in front of the scrotum, failure to wash the latter after each urination quickly leads to eczema. If the urethra opens upon the perineum behind the scrotum, simply raising the latter at urination will prevent its becoming soiled.

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[1] **See also Vol. V, Chap. II.**

THE SCROTUM[1]

General Considerations.—HEMORRHAGE.—The blood permeates the meshes of the loose cellular tissue and then clots; its resorption is a matter of weeks or even months.

INFECTION.—In the presence of a moderate infection, an adhesive plaster bridge supports the scrotum, to which an ice bag should be applied.

Suppuration usually subsides after free drainage is established. Where the skin has sloughed away, leaving a considerable defect, there is rarely lack of sufficient material for plastic closure.

The skin over the genitals is more susceptible to tincture of iodin than that anywhere else excepting the eyelids; hence, it is preferable to cleanse the parts with soap and water and then alcohol and ether (provided the patient is under narcosis). For sterilization of the skin before operating under local anesthesia, tincture of iodin well diluted with alcohol may be used, provided the surplus iodin is washed off as soon as the operation has been completed.

Hydrocele Operations. The most satisfactory and the most tedious operation for hydrocele is the von Bergmann operation. The Winkelmann or bottle operation has not given the results.

Atrophy has followed injury of the vessels.

Varicocele Operations. The high incision is generally used in varicocele operations. If the operation is properly done, there should be no complications. Ligature of the vas deferens and retraction of divided vessels occur only in the hands of the ignorant or reckless.

Castration.—The prognosis after removal of testicular teratomata is extremely grave. By the time these tumors become large enough to attract attention—their growth being the result of sarcomatous change in the connective-tissue portions—metastases are usually present in the aortic lymph-nodes and in the lungs. Local removal is, therefore, a purely palliative measure. The regression of abdominal deposits following treatment with Coley's fluid is so extremely rare that it is of practically no prognostic significance; however, the patients should be given the benefit of the doubt and should subject themselves to the Coley treatment.

After castration for tuberculosis, the patient should receive the customary hygienic treatment appropriate for all forms of this disease.

GYNECOLOGICAL OPERATIONS

Plastic Operations upon the Vagina.[2]—IMMEDIATE CARE.—After perineorrhaphy some gynecologists tied the legs together just above the knees. This is no longer done. Catheterization, if the patient is able to void, is also unnecessary, provided the parts are gently irrigated with plain sterile water after each urination. Many operators insert strips of cervical and vaginal gauze which are removed on the fourth day. This is also a minor point. Unless there is a tendency to oozing, the patients do just as well without the gauze. In the usual course of events, the bowels are moved by a mild laxative upon the fourth day after operation. It is well to soften the stools with a preliminary enema of oil or soapsuds. The perineal stitches are usually removed on the sixth day. Silkworm-gut cuts into the tissue less than silk and still less than chromic gut. The patients are not allowed to get up until the fourteenth day. After operations for complete prolapse they should stay in bed from 18 to 21 days.

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[1] See also Vol. V, Chap. I.

[2] *Ibid.*, Chap. X.

Hemorrhage from the wound is best controlled by cautiously exposing the source of bleeding, removing several stitches if necessary (the specula or retractors should be very gently manipulated), and passing a hemostatic suture. Exceptionally it may be necessary to give an anesthetic if the source of bleeding lies in the depths of the wound.

Infection is very rare, and can usually be traced to contact of suture material with the anus, which has become exposed in the course of the operation. Infection is especially apt to happen if feces, or part of the last enema the patient receives, escape while she is under anesthesia. (If the intestinal tract has been emptied by a good dose of castor oil there is much less likelihood of involuntary defecation during the induction of anesthesia than where salts and enemata have been employed.) Infection is also known to follow inadvertent penetration into the rectum by one of the deep sutures.

LATE RESULTS.—In women who have passed the menopause the triangle of denudation must be very extensive, so that only a narrow canal, sufficient for escape of secretions, is left at the completion of the wound's repair.

With the possibility of a future pregnancy, the triangle of denudation should be less, and the newly created perineal body is not so massive.

Bladder Suture.[1]—A permanent catheter of the Pezzer type (page 25) should be worn from 5 to 7 days. (With the repaired wound close to the trigone, it is preferable to use a simple rubber catheter retained by adhesive strips.) The amount of urine drained should be collected once an hour and charted. The receptacle into which the catheter is drained should be emptied every hour. By this method there is less likelihood of overlooking failure of the catheter to drain. Should stoppage occur, gently insert the catheter a little deeper, and if no urine flows, withdraw it a little. If there is still no result, make sure that the catheter is not blocked, by injecting a small amount (1 oz.) of sterile water. Stoppage is generally caused by the catheter's slipping out a little too far, or by plugging of its eye with a clot or mucus.

Repair of Vesicovaginal Fistula.—If the attempt at repair has not been successful, wait until healing has finished before doing anything further.

Repair of Ureterovaginal Fistula.—To repair a ureterovaginal fistula, it is necessary to go in from above, expose the ureter, free and re-implant it into the bladder.[2] The chief danger lies in stenosis of the ureter; hence, the patient should not be discharged until various tests have been made to ascertain the exact condition of patency (ureteral catheterization, injection of silver salts under the X-ray, indigo-carmin test, etc.).

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[1] See also Vol. V, Chap. X.

[2] See also page 131.

Treatment of Pelvic Exudate.[1] In acute inflammatory conditions of the female pelvic viscera, the treatment consists in rest and application of ice-bags. The bowels are not disturbed during the first few stormy days; relief from distention is obtained by means of turpentine stupes and the rectal tube. Later on, as the acute symptoms subside, enemata are employed.

Hot douches should be given twice a day.

When the temperature has reached normal and the peritoneal symptoms have subsided, baking may be tentatively tried. There should be 150° to 200° dry heat applied to the entire abdomen for 10 to 20 minutes. Higher temperatures are only employed when special precautions are taken for drying the abdominal skin, such as covering it with gauze or bags of anhydric calcium chlorid. In some instances this is followed by a reaction of 102° or 103°. Should this occur, it is well to wait a few days before trying the heat applications again. If no reaction occurs, the heat should be administered every day.

Treatment of Pelvic Abscess.[2] If a solitary suppurative focus has been drained, the after-course should prove uneventful. The rubber drainage tube may be removed at the end of a week or 10 days (or even sooner if there are any signs of its causing decubitus of the rectovaginal septum). Douches and irrigation keep the parts clean.

If undrained residual abscesses persist, the fever will continue, and every effort should be made to open and drain from below. If this is unsuccessful, try to establish extraperitoneal drainage through an incision parallel to Poupart's ligament. As a last resort, it may be necessary to go in from above and extirpate the diseased fallopian tubes, which usually constitute the source of infection. One must be careful to wall off the general peritoneal cavity with gauze during the operation and to establish free vaginal drainage at its completion.

Where vaginal drainage of a pelvic abscess has been established and where the purulent discharge continues over a long period of time, it usually indicates that the diseased mucous membrane of a pyosalpinx is in direct communication with the drained area and is responsible for the persistence of suppuration. If the patient is losing ground, one should not wait too long before going in from above and removing the diseased adnexa.

Curettage of the Non-pregnant Uterus.—Vaginal gauze is removed on the first day and cervical on the second after operation. Many surgeons, however, use no gauze. The patient gets up from the seventh to the tenth day.

Curettage for Retained Membranes and Placenta.—Except for a daily vaginal douche of mild antiseptic solution, the quieter the patient stays and the less she is interfered with, the better. Perforation of the soft uterine wall with a curet is not an infrequent accident. As a matter of course, do not irrigate after this accident. If the tear is small and there are no symptoms of shock or of hemorrhage, the surgeon should maintain a masterly inactivity. As a rule, the patient makes an uneventful recovery. If there are symptoms of internal hemorrhage, or if a loop of gut has been pulled down and injured, or if the uterus is badly infected, it is safer to perform immediate laparotomy and repair the damage (see Postoperative Operations).

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[1] See also Vol. V, Chap. XI.

[2] *Ibid.*

If hemorrhage persists after curettage of the uterus, it usually indicates the presence of material which has escaped removal. Besides evacuation of the uterus, hot irrigations (116° F.) of normal saline, or of 50 per cent. alcohol, or of 2 per cent. acetic acid (2 tablespoonfuls of vinegar to a quart of hot water) are excellent hemostatics. Ergot or pituitrin stimulate uterine contractions. Pack only as a last resort. Packings should never remain in longer than 24 hours after insertion for hemorrhage in a puerperal uterus (curettage). Occasionally cases occur in which all conservative measures fail, and ligation of the nutrient arteries (ovarian, uterine) or hysterectomy (vaginal, abdominal) must be resorted to.

Treatment of Puerperal Sepsis.—Should chills and fever persist after the uterus has been emptied, hysterectomy is advocated by some men for the following reasons: In some of the fatal cases of puerperal sepsis, thrombi have been found extending from the uterine vein along the iliacs and inferior vena cava to the heart. In other cases the veins have been entirely free and the spread has been by the lymphatics. In the presence of lymphatic involvement and in some of the early cases of venous thrombosis, extirpation of the diseased veins, plus removal of the uterus, has been followed by recovery. Clinically, it is impossible to distinguish between the cases of lymphatic and venous involvement. The treatment of this subject is fully covered by the remarks applying to postpartum in Vol. IV, Chap. XV.

In those cases coming to the surgeon late, where an abscess has already formed near the uterus, the patient has practically cured herself. The condition is usually localized and all that remains is to drain the abscess.

Vaginal Hysterectomy.[1]—GENERAL CONSIDERATIONS.—In the hands of any except the very expert, hemorrhage is surely the greatest danger threatening the patient after this operation. It has repeatedly occurred that blood-vessels have been divided and have retracted into the abdominal cavity without the operator's knowledge. The poor quality of the patient's pulse being attributed to postoperative shock, the usual stimulation was then instituted without effect, and either the hemorrhage was never discovered (until autopsy) or its presence was realized too late. Recognizing this danger, the habit now is to pull down the stumps of the broad ligament on either side, fastening them to the vaginal edge, and to close the peritoneal cavity, thus leaving the stumps outside of the peritoneum in either angle of the vaginal wound. The ligatures on the stump are left long so that in case any bleeding occurs, they may be used as tractors to expose the source of trouble. Furthermore, the principle of making the broad ligament stumps extraperitoneal is a good one for the reason that it leaves no raw surfaces within the peritoneal cavity.

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[1] See also Vol. V, Chap. XIII.

Should intraperitoneal hemorrhage occur, a laparotomy must immediately be done. Meanwhile much loss of blood may be prevented by manual compression of the aorta against the lumbar portion of the spinal column while the patient is being anesthetized.

If silk has been used for ligatures those which are visible in the wound should be removed on the thirtieth day (the patient goes home under ordinary circumstances on the sixteenth day), or, if they are not loose by that time, they may be taken out 3 weeks later. During the first few days after operation, if the patient does not void her urine, she should be catheterized every 5 hours.

INJURIES TO THE URETER. A. The ureter may be cut. Longitudinal cuts do not gape the way oblique or transverse ones do. If the wound is recognized at the time it is inflicted, it may be possible to repair it with fine sutures of silk similar to those used by Carrel in suturing blood-vessels. If drained with rubber dam, the wound may eventually close of itself. The evils of gauze drainage have already been enumerated.[1] If a fistula persists, it is repaired at a secondary operation.

B. If the ureter has been ligated and the opposite kidney is adequately secreting, the injury generally escapes attention until secondary local symptoms develop on the obstructed side—a matter of weeks or months. If one or both ureters have been obstructed, symptoms of suppression will call attention to this fact. Obstruction to the ureteral catheter will be found close to the bladder. The condition demands immediate exposure and relief of the obstruction either per vaginam or by the abdominal route. In rare instances the accidental ligature of the ureter is either recognized or suspected at the time it occurs; in the absence of symptoms of suppression, it is safer to wait as long as 3 to 7 days before attempting to relieve obstruction, because, while this does not materially damage the kidney, it affords the patient time for a partial recovery from the first operation.

C. The ureter may be crushed by clamps or hemostats, causing necrosis of its wall and sloughing at the end of a week or 10 days. (For closure of a fistula see Gynecological Operations and Postoperative Operations.)

INJURIES TO THE BLADDER.—Bladder injuries should be repaired at the time they are made. The subject of permanent catheter after suture of the bladder has already been discussed.

VAGINAL HYSTERECTOMY FOR CARCINOMA.[2]—The advocates for this operation claim that the late results are equally as good as those performed by the abdominal route, while the immediate postoperative mortality is much less. In the hands of Wertheim himself, mortality after the abdominal hysterectomy for carcinoma is 10 per cent., in the hands of others 19 per cent., while that after vaginal hysterectomy for the same malady varies between 5 per cent. and 10 per cent.

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[1] See pp. 126-127.

[2] See also Vol. V, Chap. XIII.

Nowadays great stress is laid upon the prophylactic X-ray treatment after hysterectomy for carcinoma.

Local recurrences in the vaginal wall should be widely excised without further delay. Cases are on record where this has been done 2 or even 3 times, each nodule with the tissue around it being removed as soon as discovered. The patients finally remained well. Parametrial recurrences are more frequent; their operability can be determined only by exploration.

Treatment of Inoperable Cases of Carcinoma.—Sloughing of the growths may be controlled by application of the actual cautery, using wooden specula to prevent scorching the healthy vaginal mucous membrane.

Acetone applications are made in the following manner: With the patient in Trendelenburg's position, through a Ferguson's glass speculum, held firmly in contact with the growth, pure acetone is poured in and left in contact with the growth for several minutes. The speculum is now tipped, and the acetone is allowed to run out. The interior of the speculum and the surface of the growth are thoroughly dried before its withdrawal. In short, every precaution is taken against injury to the vaginal mucous membrane by any of the acetone. Trichloracetic acid has also been used for cauterization of inoperable growths.

The X-ray, radium, and mesothorium, in Germany, are in great vogue. Fixed tumors often become smaller and movable under this treatment, making their removal possible. While this is rarely followed by a permanent cure, the patient's life is frequently eased and prolonged.

In the later stages of inoperable carcinoma of the uterus, the ureter may be involved, causing hydronephrosis on that side. Invasion of the bladder causes hematuria and constant tenesmus. The rectum is frequently obstructed by the growth, and the pain from involvement of the sacral nerves does not prove amenable even to the largest doses of morphin. Division of the anterolateral tracts of the spinal column (the pain-conducting tracts) has been successfully performed by Frazier of Philadelphia and Edwin Beer of New York, giving the patients peace for the last few months of their existence.

ABDOMINAL GYNECOLOGICAL OPERATIONS[1]

All gynecological laparotomies, unless there are special indications to the contrary, are allowed to sit up about the twelfth day and to be out of bed on the fourteenth day.

For care of the abdominal wound see preceding chapter.

Ovariotomy.—The postoperative course of an ovariotomy will naturally depend upon the number and character of the obstacles encountered at operation. Nothing is easier than to tap and empty a large, unilocular, non-adherent cyst and to extirpate it after ligation of its pedicle, and nothing may be more difficult than the removal of a large, adherent, multilocular ovarian cyst. The peritoneum may be denuded in countless places and the gut is not infrequently opened. There may be postoperative ileus, caused by adhesions to raw surfaces which could not be, or were not, covered over. A case is on record where a large mass ligature became loosened in the course of time and lay free in the abdominal cavity. A loop of gut worked itself into this silken circle and gave rise to ileus.

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[1] See also Vol. V, Chaps. XII-XV.

Hemorrhage from slipping of the ligature after ovariotomy is extremely rare since the Staffordshire knot has been discarded by gynecologists.

Fever may be caused by the aseptic necrosis of large stumps from the use of mass ligatures. A swelling of considerable size may be felt in the fornix of the operated side, and an abscess may even develop. This does not occur frequently at the present time, with individual ligation of vessels.

If silk is used for pedicle ligatures within the peritoneal cavity, it should be buried. The appendix is often incidentally removed in the course of gynecological operations. The only case of ileus I know following this was one in which the appendix had been ligated with No. 3 pedicle silk and its stump left exposed in the peritoneal cavity. (Where No. 3 plain catgut is used for the same purpose no adhesions result.) In this case a band, which was causing the ileus, led directly to the silk ligature. The intestinal obstruction occurred a month or 6 weeks after the original operation.

Salpingectomy.[1]—It is a mistake to drain after the removal of an old pyosalpinx, even if pus has been spilled into the peritoneal cavity. (Occasionally, in recent infections of the tube, it may be necessary to institute vaginal drainage.)

The mortality in extirpation of acute cases of pyosalpinx is very high; it is practically nil where operation is deferred until the acute stage has passed. After operation a residual pelvic exudate may be the cause of considerable pain. The exudate generally subsides under rest and application of heat.

After operations for *ectopic pregnancy* the routine measures for treating the hemorrhage and shock are instituted. A temporary high temperature is of no significance, provided the patient's general condition remains good.

Suspension Operations.[2]—VENTROSUSPENSION.—Ventrosuspension may be accomplished in a number of ways. The old-fashioned suturing of the fundus to the parietal peritoneum often may result in the formation of a long, thin band as the uterine fundus recedes. Such a band has given rise to ileus. The various modern operations for shortening the round ligaments are less prolific of trouble, provided no peritoneal pockets are formed.

VENTROFIXATION.—Ventrofixation is usually preceded by an anterior and posterior colporrhaphy and bilateral division of the tubes between ligatures close to the uterus. If, in addition to this, there is tendency to rectal prolapse, the pouch of Douglas is obliterated by superimposed purse-string sutures (Moschcowitz operation). If the anchoring sutures on the uterine fundus are not held up snugly against the abdominal wall, a loop of intestine may slip in just previous to closure and tying, and cause immediate strangulation.

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[1] See also Vol. V, Chap. XI.

[2] *Ibid.*, Chap. XIV.

Exudates in the abdominal wound are apt to follow the use of non-absorbable sutures which have been tied too tightly.

Dystocia may arise during subsequent pregnancies owing to previous ventrofixation.

Suppuration is prone to occur after Alexander's operation in which there was a great deal of injury to the tissues before the round ligament was finally located.

Myomectomy.[1]—Ochsner has pointed out that high temperatures lasting 3, 4, and 5 days after simple, uncomplicated myomectomy may be due to too tight application of the sutures in the uterine wall, causing aseptic necrosis of the constricted tissues.

Hematomata in the bed of the fibroid, with subsequent abscess, are not of infrequent occurrence. Gynecologists maintain that myomectomies are more dangerous (because of complications) than hysterectomies. During pregnancy, on account of the increased vascularity of the tissues, myomectomy is safer than at any other time.

Supravaginal Hysterectomy.[2]—The treatment of injury to the ureter has been discussed above. Injury to the bladder is repaired as soon as made, and a permanent catheter is worn for a number of days afterward. Occasionally the sigmoid may be torn open in liberating an adherent fibroid or ovarian tumor. For method of repair of intestine see the operative part of this system.[3]

Panhysterectomy for Malignant Growths of the Uterus.[4]—In addition to the injuries to the bladder and ureters (mentioned in connection with vaginal hysterectomy and abdominal hysterectomy for benign conditions) late sloughing of the ureters may occur as a result of their extensive denudation in the Wertheim operation.

After a Wertheim hysterectomy a permanent catheter should be worn for 4 or 5 days. In the course of the operation the bladder has been so freed from its surroundings that it usually is incapable of emptying itself. If the presence of the catheter is irksome to the patient, it is well to plug it temporarily, allowing a certain amount of urine to collect, thus raising the top of the bladder away from the trigone and catheter. The plug should be removed every 3 or 4 hours and most of the urine be permitted to escape.

The pelvic gauze packing[5] after a Wertheim operation is removed between the fourth and the sixth days. A day or 2 before its removal several so-called drop douches should be given to soften and loosen the gauze. A drop douche is administered in practically the same way as Murphy's proctoclysis. With the patient in the lithotomy position and under constant irrigation, each piece of gauze is spread out widely and tested to see which strands come away with the least resistance. Whatever gauze is loose should be removed until resistance is again met with. After each strip has been methodically gone over in this fashion, the operation should be repeated. At many spots where formerly the gauze was immovable, it now comes away easily. If it is still firmly adherent at several points, do not tear it loose, but leave it for removal at a second or even a third sitting a few days later. If there is no temperature, it is of little importance whether the gauze stays in a shorter or longer time.

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[1] See also Vol. V, Chap. XII.

[2] *Ibid.*

[3] The experiences of C. L. Gibson (4) in performing end-to-end intestinal anastomosis by the invagination method are worth mentioning in this connection.

[4] See also Vol. V, Chap. XIII.

[5] Some men use no gauze.

The climacteric symptoms sometimes observed after panhysterectomy gradually subside in the course of time. In spite of the extravagant claim made for the corpus luteum extract and extract made from the whole gland, these substances still occupy a doubtful position.

Rupture of the abdominal wound occurs in asthenic individuals, usually between the tenth and twentieth day, as the result of some sudden, unexpected movement. The character of suture material and the number of layers of sutures seem to have nothing to do with prevention of this accident. The ruptured wound should be closed with through-and-through silkworm gut sutures, and a drain of rubber dam should be brought out at the lower angle. As a rule, convalescence is not disturbed by this accident.

Asthenic individuals, whether thin or stout, are particularly prone to this accident, and naturally many of the cases are in those who have been operated upon for carcinoma.

THE UPPER EXTREMITY[1]

Instead of using plaster-of-Paris for immobilizing the upper extremity, satisfactory fixation may be obtained by using much lighter material. Cardboard may be cut into suitable shapes and softened by dampening with hot water, after which it is held in place by dextrine bandages. The whole mass dries in an hour or 2. Thin strips of veneering of suitable width, soaked in hot water to render them more pliable, are also very satisfactory.

Operations on the Shoulder. After operations upon the upper end of the humerus, such as resection of the shoulder-joint or reduction of an old, long standing dislocation, it is important to support the arm as well as to hold the dressings in place. A Velpeau bandage, in which the elbow remains at the side instead of being carried well in front of the body, is worn for the first few days. After this the bandage should be modified so that a certain amount of freedom is permitted at the elbow-joint and still more liberty is accorded the forearm and hand. The patient should be encouraged to exercise these to prevent their becoming stiff.

The reader is referred to any standard textbook on orthopedics for details of treatment for stiffened shoulder-joints or stiffness of the shoulder-joints following operations in this region. This will include, in addition to massage, passive motion by weight and machines, and the use of special harness for fixing the arm against the thorax in case of flail joints.

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[1] See also chapters on special subjects in Vols. I, II and III.

With the arm next to the side, be sure that the axilla is filled with a plentiful amount of loose gauze to absorb secretions and prevent maceration of the skin.

The shoulder-joint is frequently immobilized in abduction after arthrotomy or after a resection for pyarthrosis. Immobilization in abduction is also practiced after drainage of axillary suppuration. This position affords better drainage, gives less pain, and prevents the formation of contracture. For these reasons it is also used after drainage of subpectoral abscesses.

After operations upon the soft parts, where the arm may be permitted a certain amount of freedom, the type of bandage (Figs. 6 and 7) used after amputation of the breast is convenient.

Should infection follow some operation in the region of the shoulder (and by infection is not meant a temporary high temperature which subsides within a day or 2), the wound must be re-opened throughout its entire extent; it may be advisable to establish counter drainage behind. In doing this, dissection must be blunt to avoid injury of the circumflex artery or nerve. The employment of permanent suction drainage, if such is available, will often do away with the necessity for establishing a counter incision.

In clean cases, as soon as the wounds have firmly healed—that is, as early as the end of the first week—passive motion and massage are begun.

Operations for Fracture of the Shaft of the Humerus.—Non-union or delayed union are especially frequent after fracture of this bone. For treatment see Operations on the Long Bones in the preceding chapter.

Among injuries to vascular or nervous structures[1] which may be inflicted either at the time of a fracture or at operation, musculospiral paralysis (the most prominent symptom of which is drop-wrist) is the most common. If the nerve has been merely bruised, palliative measures will suffice. If it has been divided, the ends must be exposed and united without further delay. Exposure is best accomplished by working from undisturbed regions above and below toward the site of trauma.

Operations on the Elbow.—FRACTURES OF THE ELBOW.—After operative reduction and fixation of fractures of the lower end of the humerus, passive motion and even active motion within the limits of pain may be begun as soon as the cutaneous wounds have healed.

RESECTION OF THE ELBOW-JOINT.—The individual patient's occupation will largely determine whether it is better to obtain an ankylosis or a flail joint. A laborer will be better off with the former, a clerk or a musician with the latter. The text books dealing with fractures and with orthopedics in general are filled with descriptions of various apparatus for changing the angle of the elbow-joint at will. Space does not permit their description here.

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[1] See also Vol. V, Chap. XVI.

Operations on the Forearm and Hand.—OPERATIONS ON THE BONES.—After plating of either radius or ulna or both for fracture, the forearm may be supported in suitable moulded splints reaching from the elbow to the metacarpophalangeal joints. From the very beginning the fingers should be exercised daily to prevent their becoming stiff. Passive motion may be begun as soon as the cutaneous wounds have healed.

The Lane plate should not be placed directly beneath the skin. If it is placed in this situation, there is too much tension in obtaining approximation—the skin either parts or undergoes local pressure necrosis, and the plate lies exposed, leading to more or less infection. Even in the presence of the latter, the plates should be left in until union has taken place or until the screws have become loosened.

TENORRHAPHY.—Following tenorrhaphy the parts are put up in the position of maximum relaxation. After healing of the cutaneous wound, the sooner active and passive motions are begun the better.

TREATMENT OF PHLEGMONS.[1] The cardinal principles of treatment after incision and drainage of phlegmons of the hand and forearm are: (1) maintenance of free drainage; (2) moving the fingers from the very earliest possible moment.

During the acute stage it is often more convenient for the patient to keep the infected limb in a permanent bath of some mild antiseptic substance such as alum acetate solution. Wet dressings of 50 per cent. alcohol are extensively used. Remember that the fingers should always be kept separate by strips of gauze laid between them whenever it is necessary to include 2 or more digits in a bandage.

In extensive phlegmons of the fingers, hand, and forearm, simple elevation upon a pillow may not be sufficient, and it may be necessary to use vertical suspension for 24 to 48 hours.

As a rule, properly drained phlegmons, taken in time, subside within 48 hours, after which the wet dressing is no longer necessary and may be substituted by a dry dressing covered with rubber tissue or some ointment, such as boric acid ointment, blue ointment, or zinc oxid. Active and passive movements of the fingers must be diligently kept up and applications of heat, either as warm water or hot-air baths, hasten resolution and absorption of inflammatory exudates.

TREATMENT OF PARONYCHIA.—After incision of an acute paronychia, a wet dressing should be applied and the hand should be kept elevated, if necessary, by a sling. In children, naturally, a bandage must be used to keep the dressing in place. In adults, however, who wish to go about their affairs and desire to attract as little attention as possible, if the finger is covered by absorbent cotton, over which alum acetate solution is poured and over which a large rubber finger cot is then carefully drawn, so as to avoid pain, both the surgeon's and the patient's object has been accomplished. To avoid undue

[1] See also Vol. V, Chap. XVI.

maceration of the skin a 50 per cent. alcohol dressing may be used in place of the alum acetate at the end of a day or so.

If the pain of a paronychia is not relieved within an hour after incision (if the throbbing continues), it indicates persistence of retention. Either a focus of suppuration remains unopened, or else the mouth of the wound has become occluded either by gluing together of its superficial margins or by crusting over of the secretions. The arm is best carried in a sling. Do not remove drainage too early for fear of resultant retention.

OPERATION FOR SYNDACTYLISM.—After operations for syndactylism, it may be difficult to prevent re-formation of the web at the base of the fingers. If rubber bands are attached to a leather wristlet and are run between the fingers, they may prevent this (Reichel).

THE LOWER EXTREMITY[1]

SYMPHYSEOTOMY.—As a rule, union of the divided surfaces takes place without complications. Infections, non-unions, and injury either to the bladder or urethra are rare.

RESECTION OF THE PELVIS.—HEMORRHAGE, either at the time of operation or afterward (secondary hemorrhage), is effectually controlled by Momburg's aortic tourniquet. In the case of secondary hemorrhage, however, it will rarely be employed, simple digital pressure sufficing to control bleeding until the artery has been exposed and ligated.

I have in mind a case of resection of the pelvis for tuberculous osteomyelitis in which the gluteal artery was cut off almost flush with the bone at operation. Hemorrhage was controlled at the time, but secondary hemorrhage was awaited. Consequently the nursing staff and the house staff were on the qui vive for this occurrence and when it started, digital compression controlled hemorrhage until the internal iliac artery could be ligated through a laparotomy wound. The man recovered.

INFECTION.—Asepsis is difficult to maintain after operation in this region. Remember infection spreads within the pelvis as well as without it. Therefore, if it occurs, always examine either by vagina or rectum to ascertain whether an abscess has formed within the bony wall of the pelvis. In draining gluteal abscesses, one must be careful to avoid injury of the gluteal artery or sciatic nerve.

The Hip-joint.—IMMOBILIZATION.—In order to immobilize this joint after operation or for any other reason, the plaster splint should reach from the toes to the axilla. If the plaster spica reaches only as high as the waist line and does not include part of the thorax, considerable mobility of the hip is possible.

For the treatment of congenital dislocation of the hip, either after bloodless or bloody reduction, the reader is referred to any standard textbook on orthopedics.

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[1] See also chapters on special subjects in Vols. I, II and III.

RESECTION OF THE HIP-JOINT.—Resection of the hip-joint entails a great deal of shock. Momburg's elastic tourniquet is preferable to the use of Wyeth's pins for holding a constrictor from slipping. In cases where it is desirable to drain the hip-joint, it is not necessary to disturb the original plaster cast. By cutting out a sufficiently large fenestrum, the parts become accessible.

After resection for tuberculosis it is better to strive for ankylosis in good position rather than for mobility, for fear of lighting up the tuberculous process.

The orthopedic measures (apparatus and exercises) for obtaining mobility after resection cannot be described here for want of space.

Extirpation of Buboes.—The ideal method is to extirpate these in an aseptic fashion without opening the foci of suppuration, after which the skin is sutured and primary union is expected. Where this is impossible, the abscess should be laid open by a generous incision and care should be taken to scrape out all the diseased gland tissue, making sure that all the nooks and crannies are adequately drained.

Operations Upon the Blood-vessels.—EXTIRPATION OF VARICOSE VEINS.—The operation for extirpation of varicose veins should always include ligation of the saphenous vein close to its junction with the femoral vein (Trendelenburg's operation). The leg should be elevated and immobilized for 10 days. After the first dressing, there may be some marginal necrosis with sloughing. The sloughs should be treated in a conservative manner until they have become clearly separated, when they should be cut loose and removed. The treatment of the ulcerating defect left behind requires no special comment.

Should there be a tendency to recurrence in the course of time, a bandage of woolen crêpe ("Ideal" bandage is as good as any) affords a great deal of relief; it should reach from the toes to the knee or even higher if necessary. Such a bandage is more easily adjustable to the patient's individual anatomy than an elastic stocking; it lasts longer, is cheaper, and cleaner.

An Unna's paste bandage is another means of supporting the leg (see below, under Effusions of the Knee-joint).

LIGATION OF THE FEMORAL VEIN.—Ligations of the femoral vein following injury either at hernia operations or during the extirpation of inflamed inguinal nodes have a surprisingly low mortality as compared with ligation of the femoral artery. The limb should be kept well elevated, quiet, and warm. In due course of time the edema and cyanosis subside. Gangrene is rare.

It is preferable to compress the vein above and below the point of injury and to suture the wound according to the method of Carrel rather than to resort to ligation. Even in the presence of infection this has been frequently successful.

LIGATURE OF THE FEMORAL ARTERY.—Ligature of the femoral artery is far more apt to be followed by serious consequences (death of the limb) than ligature of the vein. If possible, accidental wounds should be closed by the Carrel suture. In those cases where the artery lies close to a large tumor or where an aneurysm is to be extirpated, gradual narrowing of the arterial lumen before operation will give the collaterals time to develop and will thereby minimize the chances of insufficient nourishment to the distal part of the limb.

SAPHENOFEMORAL ANASTOMOSIS.—Saphenofemoral anastomosis for arteriosclerotic gangrene or thrombo-angiitis obliterans, while it affords the patient temporary relief, is almost never followed by a permanent cure. Certain operators claim equally good results by simple ligation of the femoral vein in Hunter's canal. The usual result of the Wieting operation is that the patient acquires an arteriovenous aneurysm in addition to his original complaint. Amputation gives permanent relief. (See Amputations in preceding chapter.)

Operation for Muscle Hernia.—After operation for muscle hernia the patient should not use his leg for at least 3 to 4 weeks, in order to allow the fascial wound time for firm consolidation.

The Femur.—OPERATIONS FOR FRACTURE OF THE FEMUR.[1]—Lambotte flexes the knee sharply, so that the heel nearly touches the nates, until the cutaneous wound has healed. As soon as this has occurred, the limb is supported on a suitable posterior splint and passive motion is begun. Lane likewise uses no plaster cast, contenting himself with a voluminous gauze dressing and begins active and passive motion at the earliest possible moment. Both these operators rely upon their plates as true internal splints.

Opposed to these are the majority of American surgeons, who apply a plaster cast, leaving it on for at least 6 weeks, during which time the patient is kept in bed.

More or less delayed union invariably is the outcome.

Lane's and Lambotte's dicta have not been followed. Instead of using as large plates and as many screws as possible, as small plates and as few screws—barely adequate for immediate fixation—are employed. Instead of instituting active and passive motion as soon as the cutaneous wounds have healed, long immobilization in plaster is the rule.

The operated limb should not be allowed to bear weight for at least 6 months, for callus has been known to yield and permit angulation as late as 6 or 8 months after operation.

Getting the patient out of bed on crutches at the earliest possible moment is another most important factor in promoting early union.

OSTEOTOMY FOR OSTEOMYELITIS.—Osteotomy for osteomyelitis, chronic or acute, has been treated in the preceding chapter. The powerful musculature of the femur tends to cover in the bone. It is important to keep the wound wide open until one is sure that all sequestra have become loose and that the remaining bone is covered with healthy granulations.

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[1] See also Operations on the Long Bones in the preceding chapter.

The Knee.—REMOVAL OF SEMILUNAR CARTILAGES.—As soon as the cutaneous wound has healed, passive and active motion may be begun within limits and gradually increased as time goes on.

OPERATIONS FOR FRACTURE OF THE PATELLA.—As in operations for fracture of the femur, divergent after-treatment is followed by Lambotte and by the majority of other surgeons. Lambotte encircles the reduced fragments by a loop of strong copper wire almost ⅛ in. thick, plated either with silver or gold (Cerclage). He gets the patient out of bed and starts him walking as soon as the cutaneous wound is healed.

Other operators either content themselves with suturing the bones in their proper place by chromic sutures, approximating the tear in the lateral fascial expansions, or, in addition to this, drilling the bone fragments and uniting them with heavy chromic sutures. The knee is then kept immobilized for 3 or 4 weeks, at the end of which time moderate passive motion and massage are begun. It is rare to see such a patient able to flex his knee to a right angle before the end of 6 months.

DRESSINGS WHICH COMPRESS AND PARTLY IMMOBILIZE THE KNEE-JOINT.—After aspiration for an effusion (of serum or blood) of traumatic origin, the following dressing should be applied: A layer of flannel bandage or of non-absorbent cotton placed next to the skin, covering the joint and the limb just above and below it, over which a rubber bandage is then applied. Under this firm compression and warmth (the rubber gives the effect of a Priessnitz pack) the effusion usually subsides in a few days. After the first day or 2, the rubber bandage may be replaced by one of woolen crêpe.

The knee should practically be immobilized, although the patient may be allowed to stand on it, for several weeks. At the end of this time small movements are tentatively begun, but instantly cease upon recurrence of effusion, when compression and fixation must again be resorted to. This class of cases is particularly difficult to treat because the patients cannot understand why they are forbidden to use a knee which causes no pain.

UNNA'S PASTE DRESSING after aspiration of serous effusion of the knee-joint has been successfully used by Heidenhain (after Reichel). The dressing is applied at the end of the third week: it reaches from the toes to high up on the thigh. The patient is allowed to walk, but is cautioned against energetic use of the immobilized limb. The dressing is changed every 8 to 14 days; the whole treatment extends over a period of from 4 to 8 weeks.

After thoroughly cleaning the skin, that part of the limb which is to be encased in the dressing receives a generous coating of warm fluid Unna's paste [1] (composed of zinc oxid and gelatin, āā 20, glycerin and water, āā 80). A dextrine bandage, dipped in water, is immediately applied in one tour from the toes to the upper limit of the anointed area. Another coat of Unna's paste is then applied, and the bandage is run down to the toes. This is repeated until 4 layers of smoothly applied bandage are superimposed upon each other. To prevent the Unna's paste bandage sticking to the patient's clothes, a dry gauze or muslin bandage is put on over it. It takes some time for the dressing to dry. Personally, I have found that it is more comfortable for the patient to have a layer of surgeon's lint applied to the skin before the Unna's paste applications are begun. The removal of the dressing is much less uncomfortable.

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[1] The Unna's paste is conveniently kept in an ordinary double boiler; it is melted just before using and is applied with an ordinary paint brush. Be careful to see that it is cooled down after being melted, so as not to burn the patient.

TREATMENT OF PYARTHROSIS.—Irrigation of the joint through trocars inserted on either side of the patella is not infrequently followed by a subsidence of the infection and ultimate recovery of perfect function in children. In adults this is rare.

While it does not change the character of the inflammation, the effect of the Bier hyperemic treatment upon the pain of gonorrheal infection of the knee-joint is truly remarkable. Within 2 hours after its application the patient is comparatively comfortable.

For details of the Bier treatment the reader is referred to the remarks on The Extremities in the preceding chapter.

After the Mayo operation for pyarthrosis (laying the knee open by a transverse incision and fixing it in flexion), the knee should be extended as soon as the acute symptoms of infection subside and healthy granulations appear. It is then allowed to ankylose in the position of nearly full extension. It goes without saying that straightening of the knee must be done under an anesthetic.

RESECTION OF THE KNEE-JOINT.—The surgeon should be on his guard against posterior displacement of the head of the tibia upon the stump of the femur. A lateral X-ray view should be made as soon as the plaster cast has hardened, to make sure that the proper position exists. The old method of transfixing the tibia and femur with steel nails placed at right angles to each other, which are withdrawn at the end of 2 or 3 weeks, has always given good results in preventing this. When the time has come for removing the nails, their ends are exposed through the plaster fenestra on either side (the original cast is not disturbed), the gauze covering the end is removed, and a liberal application of tincture of iodin is made to the nails and to the adjacent skin. The heads of the nails are then firmly grasped, rotated, and withdrawn. A little iodin is then injected into the nail holes, and a wet dressing is applied for a few days, at the end of which time the nail hole closes of itself. No suppuration is to be expected. A light posterior splint should be worn for a long time to prevent the development of a *secondary contracture*. The sooner the patient is gotten out of bed on crutches, the quicker consolidation may be expected. As the chief growth of the lower extremity takes place from the lower epiphysis of the femur and the upper of the tibia, it is important to preserve as much of the epiphyseal line as possible at operation in children to prevent shortening. (See also general remarks upon Resections in the preceding chapter.)

Operations on Fracture of the Leg.—As a rule, if the tibial fragments are properly reduced, the fibular ones may be practically disregarded. As in fractures of the ulna, the plate must not be placed directly beneath the skin because of the risk of decubitus or sinus formation. If union is somewhat delayed, it is well to try a few weeks' course of hygienic measures, together with local light, often repeated hammering of the site of fracture with a percussion hammer, or the injection of some of the patient's blood between the ends of the non-united fragments. Bone grafting should be resorted to in case these measures fail.

Operations Upon the Tarsus.[1] Removal of the astragalus deserves no special mention. If the foot has been immobilized in the proper position and no infection occurs, the sooner attempts at weight bearing are begun after the cutaneous wounds have healed, the better.

WLADIMIROFF-MIKULICZ RESECTION. No attempt should be made to bear weight until a firm, bony synostosis has taken place. In the meantime, one must guard against displacement of the fragments.

The Toes. OPERATIONS FOR HALLUX VALGUS. The great toe should be kept on a line with the internal margin of the foot by padding between it and the next toe in addition to applying a light splint.

OPERATIONS FOR HAMMER-TOE. A proper position is maintained by holding the toe down upon a sandal with suitable perforations, through which a tape, encircling the summit of the resected joint, is drawn and tied on the sole side.

INGROWING TOE-NAIL. If taken in time, operation is rarely necessary for this condition. If the nail is raised out of its bed and its sharp margin is either protected with gauze or with sealing wax and is made to project beyond the point where it has been accustomed to eat into the flesh of the toe, the necessity for operation is usually avoided. If, on the other hand, operation has been performed in the presence of infection, the after-treatment must be directed toward preventing any stagnation of secretion. Frequent change of wet dressings for the first few days is followed by the application of a suitable dressing of some antiseptic salve. The patient should be instructed in the proper cutting of the nail to prevent recurrence.

After both bunion, hammer-toe, and ingrowing nail operations, the surgeon must see to it that the patient wears shoes of the "Ground Gripper" or "Coward" type to prevent the undue crowding of the toes.

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CHAPTER III

POSTOPERATIVE OPERATIONS

LUCIUS W. HOTCHKISS

Postoperative operations are operations which are rendered imperative by the occurrence of some accident, injury, or complication during the course of convalescence from a primary surgical procedure.

Such operations may be called for as the result of errors in judgment, errors in technic, carelessness, or conditions over which the surgeon has no control or which have made the primary operation, of necessity, incomplete.

Postoperative operations, therefore, are often operations of urgent necessity, and many of them are of major extent and importance, calling for the highest degree of skill, judgment and ability in their execution. Nothing, perhaps, tests the courage and general ability of the surgeon more than to be called upon to perform one of these major emergency operations, often under adverse conditions, for some serious complication arising unexpectedly during the course of convalescence from an otherwise successful primary operation.

For an operator with clean-cut, rapid and efficient methods of work, of steady brain and hand, who can act promptly but not hastily, and with a definite purpose as to what may be accomplished, such operations offer a field of promise in the reward of many lives saved. Surgical literature abounds in the description of brilliant work of this character and is an incentive to effort to extend the safe boundaries of this promising field of endeavor.

Indications for Postoperative Operations.—Generally speaking, secondary operations are called for by reason of the occurrence of hemorrhage, sepsis, obstruction to the circulation of blood with resulting gangrene, obstruction to the flow of the contents of the intestinal canal, or of the ducts of various organs or glands, for the removal of foreign bodies accidentally left in the field at the time of the primary operation, and for some other conditions not properly or strictly falling within any one of these divisions.

Postoperative Hemorrhage.—There are few accidents in surgical practice more serious to the patient and to the reputation of the surgeon, also, than the unexpected occurrence of severe postoperative hemorrhage several hours after the performance of an otherwise successful operation in which no such result has been anticipated or could properly have been looked for.

Too great care can never be used to stop all bleeding at the time of the primary operation, especially when such bleeding is within the cavity of the abdomen. "The little bleeding which will soon stop" should never be disregarded here or in any other situation where it is out of sight and prompt control. A little extra pains to make every such wound a dry wound never brings regrets and is worth all the time and effort expended. It makes no difference whether the ligature slipped because of careless or inefficient application, or whether small bleeding points were overlooked or disregarded, the hemorrhage which follows may be fatal and constitute a surgical tragedy never easy for the surgeon to explain satisfactorily or for the patient's relatives to forgive.

SECONDARY HEMORRHAGE.—True secondary hemorrhage is still occasionally observed, though happily but rarely, save in infected fields where it is not always possible to guard against it. It may follow aseptic ligation of some of the larger arterial trunks, from cutting through of the sterile ligature, as in operations for aneurysm, though it no longer constitutes the real menace it did in pre-antiseptic days, when the "coming away of the ligature," about the ninth day, was watched with the greatest anxiety.

TREATMENT OF POSTOPERATIVE OR "REACTIONARY" HEMORRHAGE.—Exposure and ligation of the bleeding point, either through the re-opened operation wound or other incision, constitute the proper treatment for this emergency, whether the bleeding is in the extremity or the pelvis. Preliminary transfusion of blood may be called for when the patient's condition approaches exsanguination, and infusion of normal sterile salt solution either into the vein or subcutaneously is often a ready and efficient means of tiding the patient over a dangerous period. The application of Momberg's belt, to secure temporary hemostasis within the pelvic cavity while preparations are being made to reopen the abdomen, may be effectual, or manual pressure upon the lower aorta in a thin individual may answer the same purpose, when a further loss of blood would render futile any secondary operation for its relief. That is to say, the surgeon, in some of these cases, is confronted with a condition which puts him in a serious dilemma. If he operates the patient dies; if he does not operate the same result occurs. Obviously, then, any means which can be found to prevent further loss of blood, or which can put more blood or fluid into the patient's circulation, may be vital before the operation of exposure and ligation of the bleeding vessel can be safely accomplished.

Postoperative or secondary hemorrhage in infected fields, as in extensive cellulitis of the forearm, occasionally occurs and may be controlled by pressure. This control is generally temporary, however, and the bleeding soon begins again with the washing away of the infected clot in the mouth of the divided vessel. Ligation in situ is sometimes easy and sometimes, on account of the softened or sloughing tissues surrounding the bleeding point, very difficult. Some form of suture ligation which includes the surrounding tissue in the grasp of the ligature will often suffice. This is called the *umstechungs* knot by the Germans, and is frequently effectual in infected fields and elsewhere to control serious bleeding. Occasionally, of course, where the local conditions are such that ligation in situ is impossible, the trunk of the artery will have to be ligated in its continuity, somewhere above the infected field, as occasionally happens, for example, in the hemorrhages from the palm in severe infections of the hand.

Elsewhere than on the surface of the body, where the bleeding may be quickly recognized, the problem of treatment, it will be seen, becomes often very complex and calls for rare judgment on the part of the surgeon. Within the cavity of the abdomen or the rectum, large quantities of blood may accumulate without showing any tell-tale stain upon the dressings, the first indications being the restlessness, "air-hunger," feeble pulse and extreme pallor and weakness of the patient.

In true secondary hemorrhage, which occurs, as a rule, several days after an operation, smaller "signal bleedings," as they are called by the older writers, frequently precede the final hemorrhage and should never be disregarded by the surgeon, although they are frequently easy to control by pressure. Their appearance should be promptly followed by a search for and ligation of the bleeding point before the patient is fatally weakened.

Postoperative Wound Infection.—Wound infection is another fertile cause of postoperative operations and should be early recognized and promptly dealt with.

The degree, the character, the depth and the situation of the infection will obviously determine the character and extent of the operations for its relief. Such operations, minor and major, will be dealt with more at length under the proper regional heads. They are of all degrees of extent and severity and form an interesting and important study.

Postoperative Obstruction.—Under this head may be included the treatment of the obstructions to the circulation of the blood arising from accidental wounding of important vascular trunks, obstruction to the flow of intestinal contents, as in postoperative ileus, as well as the obstruction of ducts such as the ureter and the biliary and salivary ducts by inclusion or division.

The postoperative surgery relating to the removal of foreign bodies, the division of nerve trunks, and the miscellaneous conditions which cannot be classified, will be treated under the proper regional heads.

POSTOPERATIVE OPERATIONS IN THE REGION OF THE HEAD AND NECK

THE HEAD

Secondary operations upon the head may involve the scalp, the skull, the blood and air sinuses of the cranium and face, and the brain.

Operations on the Scalp and Skull for Postoperative Hemorrhage and Infection.—Secondary operations upon the scalp are sometimes necessitated by reason of the occurrence of hemorrhage or infection, which may follow the suture of accidental scalp wounds or of operative wounds made in the removal of tumors of the scalp or for conditions within the cavity of the skull.

After trephining for compound depressed fracture of the skull, with removal of depressed fragments which had penetrated the brain, it was found in one case, on examination of the skull by the X-ray, that some imbedded fragments remained behind. This necessitated a secondary operation under the guidance of the skiagram, which consisted in the removal of the fragments which were not found at the primary operation.

Although many of the postoperative operations upon the scalp and skull consist in opening the wound and securing the bleeding point or providing drainage in the event of infection, they are often of the greatest importance to the patient in that they may save him from more serious trouble.

Hemorrhage after suture of wounds of the scalp is, as a rule, promptly detected and controlled by pressure or ligation. Infections spreading beyond the edges of the wound generally call for removal of the sutures and provision for wound drainage, or, in the case of deep spreading infections beneath the aponeurosis of the occipitofrontalis muscle, wide and deep incisions may be called for to prevent extension of the infection to the deeper and more important structures within the skull.

Postoperative operations following trephining for compound fractures, for the drainage of cerebral abscesses, or the removal of tumors of the brain or its membranes, may have to be done for the relief of pressure due to hemorrhage or for the revision of drainage.

In the event of postoperative hemorrhage, the skull may have to be re-opened and an endeavor made to secure the bleeding point by suture ligation or, if this is not practicable, to remove the clots and control the bleeding by the pressure of a light pack carefully placed.

Postoperative intracranial infections, unhappily, are not amenable, to the same degree as elsewhere, to the rule of free incisions and drainage for the relief of tension and the prevention of further spread. When such a complication occurs, however, an endeavor should be made to secure free drainage by wide opening of the wound and the introduction of a drainage tube or light gauze packing.

The peculiar structure of the brain tissue, however, renders it singularly non-resistant to infections, and this fact in itself calls for the most rigid aseptic technic in all operations within the skull, as it is much easier to prevent infection at the original operation than to cope with it successfully after it is once established.

Postoperative operations following partial mastoidectomy for mastoid and middle ear suppuration may be called for by reason of the later development of thrombosis in the lateral sinus. Such operation consists in exposing and opening the lateral sinus, cleaning out the clots, and in some cases the ligation or removal of the internal jugular vein in the neck. The technic of these operations is described elsewhere and needs no further description here.

Postoperative operation for the relief of paralysis of the facial nerve, due to accidental division of the facial trunk in operations upon the mastoid, is sometimes called for. As it is generally impossible to find and join the ends of the divided nerve under these conditions, the operation of faciohypoglossal anastomosis has been devised, whereby the exposed distal end of the divided seventh nerve is sutured to the proximal end of the hypoglossal nerve. This procedure, which is fully described under the proper head, often results in partial restoration of function, though, as a rule, the results are never quite perfect.

Secondary Operations for the Repair of Skull Defects Following Operation. —Large defects of the vault and frontal regions of the skull may be repaired by the introduction of plates of celluloid properly shaped to fill in the defect, or sometimes by the use of metallic plates, as of silver or other metals. Such plates may remain in place for a long time and give no trouble and serve as a protection to the underlying brain, or they may cause considerable irritation and have to be removed. Röpke has proposed, for this purpose, the introduction of an autoplastic graft derived from the plate of the scapula.

POSTOPERATIVE OPERATIONS IN THE NOSE, MOUTH, PHARYNX, ETC.

Operation for Postoperative Nasal Hemorrhage and Infection. Operations in the nose may be followed by severe hemorrhage, which may urgently call for relief. This is often best obtained by tightly plugging the nares, as it is not feasible, as a rule, to employ the ligature in this situation.

Under local anesthesia with novocain and adrenalin, and with the aid of a good strong light, plugging the nares by the careful introduction of gauze plugs from the front of the nose, until the cavity is completely filled, is often effectual in controlling the bleeding. Plugging the posterior nares, an operation already described elsewhere, is frequently necessary and generally effectual, although its performance may be very disagreeable to the patient and sometimes quite difficult for the surgeon to execute properly.

Postoperative nasal infections may be very serious by reason of their occasional tendency to spread upward through the cribriform plate of the ethmoid and to involve the membranes of the brain. Postoperative revision of drainage may sometimes be necessary in these cases and may involve the removal of bone for the accomplishment of this purpose. This sort of procedure not infrequently follows operations on the frontal and maxillary sinuses and upon the ethmoidal cells. Such operations are described elsewhere.

Secondary operation for the removal of necrotic bone after Killian's operation for frontal sinus infection. This occurred in a personal case, where the plate of bone forming the cerebral face of the frontal sinus was discovered, at the time of primary operation, to be entirely necrotic but still somewhat adherent to the dura. A secondary operation for its removal, together with revision of drainage through the ethmoid cells into the nasal cavity, was successfully done several days later.

Secondary operations for harelip and for cleft palate, due to failure of the primary operation, are common enough, and the secondary operation may have to be variously modified by reason of the loss of tissue in the performance. The question of repair in all these cases is discussed under the chapter dealing with plastic operations for congenital deformities of the lips and of the soft and hard palate.

Operation for Salivary Fistula.—Secondary operation for the repair of a salivary fistula, due to the accidental or unavoidable wounding of Stenson's duct during the course of some operations upon the face, is occasionally called for. There are various methods devised to relieve this very troublesome complication, described under their proper heads and needing no further description here.

Operation for Hemorrhage Following Tonsil Operations.—After the operations of tonsillotomy and tonsillectomy, severe postoperative hemorrhage sometimes occurs, calling for prompt and efficient measures for its relief, as the patient may bleed a large amount from an apparently insignificant tonsillar vessel and it is important to lose as little time as possible in stopping the flow of blood. At times it may be possible to see and grasp the bleeding vessel through the wound with forceps and to tie it, or it may be included in some variety of suture ligature which surrounds it and at the same time grasps enough of the tonsillar stump to prevent its slipping. Pressure with the finger or pads, and combined pressure from both within and without the mouth, by means of a special instrument made for this purpose, have all been used with good effect in controlling alarming postoperative hemorrhages from the tonsil. It is well to remember that postoperative bleeding after the removal of tonsils and adenoids may occasionally proceed from the posterior pharyngeal wall and be due to the presence of a tag of partially removed soft adenoid. In these cases a sweep of the finger will often discover and remove this tag and promptly stop the hemorrhage.

When, in spite of various measures, the bleeding still continues, as may be the case where the tonsillar base is sloughy and cannot support a ligature, and when pressure has been tried and failed to control the recurring loss of blood, the final resource left to the surgeon is ligation of the external carotid artery. Extreme reluctance to take this step has perhaps occasionally led to needless sacrifice of life, although the too long postponement of the operation and its execution finally, under the most unfavorable conditions for the patient, may lead to equally bad results.

The operation of ligation of the carotid needs no special description here as it is dealt with in a separate chapter. The question of the choice of an anesthetic, however, may be of great importance under these conditions, and should be based on careful judgment as to the needs of the case in hand. The same is true of the necessity or expediency of blood transfusion or of saline infusion preceding the operation in these cases. One or the other is quite apt to be necessary, and it is well to remember that the subcutaneous injection of normal sterile salt solution, which can generally be quickly obtained anywhere, is often a saving measure and has many times demonstrated its usefulness.

Control of Hemorrhage Following Removal of the Tongue.—Postoperative operations for the control of severe hemorrhage following removal of the tongue for carcinoma are of occasional occurrence. Where a traction ligature has been left in place so that the stump of the tongue may be pulled forward, the bleeding point may often be easily seen and secured before much blood is lost. If there is no such ligature the finger hooked around the stump of the tongue will serve in the emergency to pull it forward into view, and allow the bleeding vessel to be caught and tied. Ligation of the lingual or external carotid may be necessary under these conditions, where the stump of the tongue is too soft to hold a forceps or ligature, but temporary hemostasis at least may generally be secured by pulling forward the base as above described, even if the ligation in continuity of the other vessels is deemed expedient. Local application of a solution of cocain to the pharynx will greatly simplify this procedure.

POSTOPERATIVE OPERATIONS IN THE NECK

After operations in the neck, the occurrence of hemorrhage, infection, or pressure obstruction of the larynx may call for prompt measures of relief.

Operation for Postoperative Hemorrhage.—Postoperative hemorrhage may necessitate the re-opening of the wound and securing the bleeding vessel. In true secondary hemorrhage, such as may occur in infected fields, the problem is not always so simple, as the tissues are soft and hold a ligature with difficulty. Some form of suture ligatures such as the *umstechungs* knot, is generally effective, however, although occasionally a main arterial trunk may require ligation to control the bleeding.

Secondary hemorrhage after the operation of ligation of the carotid or subclavian artery in the case of aneurysm of one or the other of these vessels, for example, may occur from the cutting through of the aseptic ligature, but this accident is fortunately quite rare. When it does occur, the field must be well exposed by opening the wound and applying the ligature higher up, temporary hemostasis having in the mean time been secured by firm pressure by the finger or a pad thrust into the wound and held there until preparations for proximal ligation of the bleeding artery can be made. In practice, this is sometimes impossible when the bleeding is sudden and overwhelming.

Postoperative infections in the neck are perhaps more common than and fully as important as postoperative hemorrhage. It is very essential to recognize early the presence of spreading wound infections along the planes of the deep cervical fascia and to appreciate also the importance of the early relief of tension, by promptly re-opening and draining the wound, and where the process is rapidly extending, the necessity of making free and deep incisions, to prevent the extension of the cellulitis to the

mediastinum and the involvement of the larynx. Repeated deep incisions may be necessary to prevent fatal damage.

It is amazing to think how wholly inadequate are the incisions which are sometimes made for the relief of some of the cases of deep cervical cellulitis, with what apparent reluctance they are sometimes resorted to, and how much reliance seems often to be placed upon the efficiency of some advertised serums and vaccines of more than doubtful value.

A considerable experience, extending over many years in the surgical service of a large general hospital, has led me to the firm conviction that there is still much need of urging the truth of the ancient surgical maxim, "*Ubi pus, ibi evacua,*" and of deploring the present tendency in some quarters to rely upon the use of some of the quite unreliable serums and vaccines, in the face of conditions which would seem sufficiently obvious to suggest the free use of the scalpel and the drain. It is quite remarkable how many of these cases are lost for the lack of application of sound principles of treatment in the earlier stages.

For example, a man recently applied for treatment at the hospital for an extensive, spreading, deep cellulitis of the neck, following a tonsillar infection. His whole neck was brawny, red, and painful, the patient was evidently septic, and his condition very poor. His previous treatment had apparently consisted in the making of 1 small incision in the upper part of the side of the neck and in the use of a commercial serum of vaunted efficiency.

In spite of very extensive and deep incisions, which revealed the presence of pus everywhere, the patient succumbed to septicemia in a few days, a tracheotomy having been done in the meantime to prevent asphyxia. Deep cervical cellulitis, therefore, postoperative or secondary to local or more distant points of infection, should be recognized early and treated as a dangerous condition.

After the operation of laryngectomy, deep spreading cervical cellulitis may involve the anterior mediastinum and lead to a fatal result. Its prevention may sometimes be effected by adopting the method of Crile, who proposed doing laryngectomy in 2 stages, at the first operation freeing the larynx and packing the surrounding wound with iodoform gauze for a few days, to establish the formation of a resistant wall of granulations, and then proceeding to extirpate the larynx at the second operation, with little fear of infection of the deeper planes of the neck.

Sauerbruch has recommended opening and draining extension abscesses in the anterior mediastinum by trephining through the sternum.

Rehn recommends splitting the sternum to secure an approach to this field for the same purpose.

Laryngotomy or tracheotomy may become suddenly urgent in any case of deep spreading cellulitis of the neck, especially in the form known as Ludwig's angina, which spreads from the floor of the mouth. The operation is essentially an emergency one under these conditions, and must often be done without previous preparation, although it is the rule in these cases, in hospital practice, to have the instruments at hand in view of the possible emergency.

The operation may often have to be done without an anesthetic and not infrequently in the sitting posture, as the patient is in great distress and cannot lie down. The quickest way to the admission of air to the sufferer's lungs, under these conditions, is to make an opening through the cricothyroid membrane and hold it open with the handle of the scalpel, for example, until some form of tube can be found and introduced.

A warning against opening through the thyrohyoid membrane above the vocal cords may seem unnecessary in this connection, but this has been done inadvertently many times in the excitement of the emergency and, of course, without any relief to the patient.

A proper incision and an opening into the trachea are readily executed, even with a penknife, if the operator keeps his head during this most distressing occurrence.

Postoperative plastic operations for the relief of contractions in the neck, following perhaps sloughing after primary operations of various kinds, may occasionally be necessary. The Z-shaped incision for the relief of postoperative contractures in the neck and axilla will serve as a familiar example of what may be done to relieve some of these cases. The operations for the various contractures in this region, which as a rule follow traumatisms or burns more frequently than operations, are described in a separate chapter.

Operation for Thrombosis of the Internal Jugular Vein. When this occurs after an operation for thrombosis of the lateral sinus, ligation and removal of the vein from the mastoid to its point of junction with the subclavian is necessary. This, of course, calls for an extensive dissection of the neck, the vein being removed from below upward after placing the lower ligature below the clot and as close as practicable to the point of junction with the subclavian vein at the root of the neck.

POSTOPERATIVE OPERATIONS UPON THE THORAX

Operations for Postoperative Hemorrhage.—It occasionally happens, after an operation so common as excision of the rib for drainage of an empyema, that secondary hemorrhage occurs, which may be severe and even fatal in its results if not promptly recognized and stopped. Such hemorrhage, following the rule of true secondary hemorrhage in an infected field, usually begins several days after the primary operation and may not at first be very considerable. Pressure may sometimes be temporarily effectual, but in some cases, in spite of pressure packs which are so firmly placed that they distress the patient very much, blood still escapes into the cavity of the pleura, and the patient soon shows the effects of hemorrhage. That is to say, the extent of the hemorrhage may be partly concealed for a time and the dressings show only moderate bleeding, when in reality a large amount of blood may have escaped into the chest. Hemorrhage in an infected field of this character usually recurs and the patient will lose a great amount of blood unless prompt means are adopted to stop it. Sharp hemorrhage following the removal of the pressure packing should be sufficient notice to avoid further delay. This warning is frequently neglected and the patient comes to a dangerous condition from which it is not always easy to rescue him.

The only effectual way to deal with these cases is to expose and tie the bleeding vessel. This generally necessitates an extension of the original incision along the rib and possibly a wider removal of the bone, in order to place the ligature about the artery.

Secondary Operations for the Revision of Old Empyema Cavities.—In cases where the lung is held firmly down by adhesions and is unable to expand, the operation of decortication, as proposed by Delorme, or some of the modifications of this method may be used. Scoring the pulmonary pleura by cross incisions will frequently suffice and in small cavities is much simpler and often entirely effectual in securing the expansion of the lung.

Where the lung is completely collapsed and cannot expand, wide excisions of the ribs and chest wall, after the method of Schede, may be necessary in order to obliterate the dead space. These operations are described elsewhere in detail. Secondary operation for the removal of a carious rib is occasionally necessary after drainage of an empyema. This presents no special difficulties.

Secondary operations for carious ribs underlying tuberculous abscesses of the chest wall and overlooked at the time of the primary operation, from the fact that such abscess may be at some distance from the bone focus of infection and connected with it by a devious sinus which is easily missed, form a class of operations of considerable importance and some difficulty. For example, a long sinus may extend from the floor of one of these cold abscesses of the front or back of the chest, pass up behind the rib exposed, which is not infected, and lead to a rib or ribs above or below or to the transverse process of one of the dorsal vertebræ. The following out of one or more of these sinuses until the primary focus of the trouble is reached may necessitate long incisions and a very careful search. In some of these cases repeated operations have to be done.

Postoperative operations for the drainage of encapsulated collections of pus during the drainage of an empyema present no great difficulties after the pus collection has been located by the needle, although some of these collections may be quite difficult to locate.

Secondary operations for the relief of lymph stasis of the upper extremity following the radical removal of the breast and axillary contents for carcinoma, are occasionally done but with very variable success. Handley's operation, which consists in the introduction of sterile threads of tubular silk from the root of the neck down along the subcutaneous tissues of the arm in an attempt to form artificial lymph channels which will re-establish the lymphatic circulation which has been obstructed by the operation, has not proven permanently successful.

Another method, described at length in the *Centralblatt für Chirurgie*, 1912, seems to give greater promise. This operation, in brief, is similar to the one which has been successfully performed in elephantiasis of the lower extremity. It consists in transplanting strips of fascia from the superficial to the deeper planes of the arm by leading them down through the deep layer of muscles or fixing the free ends in holes bored in the bone, thus establishing a connection between the superficial and deeper planes of connective tissue.

POSTOPERATIVE ABDOMINAL OPERATIONS

Secondary operations are frequently necessary after primary laparotomy, partly because of the complex nature of the abdominal contents and partly because of the fact that incomplete abdominal operations are often necessitated by the nature of the case.

Secondary Suture of Abdominal Wounds.—Secondary suture of abdominal wounds constitutes an operation of considerable importance and requires care and judgment. Carelessly sutured operation wounds, the use of improper suture material, too early removal of the sutures, hemorrhage, infection, increased intra-abdominal tension from distention, retching and vomiting, weakness and emaciation in carcinoma - all or any of these factors may contribute to the causation of re-opened wounds of the abdominal wall.

Secondary closure of infected open abdominal wounds may be attempted when the wound has become clean and covered with healthy granulations, by strapping the granulating surfaces tightly together with sterile adhesive plaster or by through-and-through sutures of silkworm-gut, silver wire, or catgut, according to the preference of the operator.

As a general rule, however, it is better to bring the peritoneal edges together carefully in these cases, fortifying the suture line with through-and-through tension sutures, and to close the remainder of the wound by layers.

Ruptured primary union in abdominal operation wounds may occur, and prolapse of the intestines follow. Prompt recognition of this accident is necessary.

A general anesthetic may be advisable for the effective repair of these cases, although local anesthesia with novocain may suffice. The prolapsed intestines should be carefully washed with a warm saline fluid, soft adhesions being separated and any foreign particles removed from their surface, and then carefully replaced within the abdomen; if possible, the omentum should be drawn down over them. The abdominal wound should then be repaired by careful layer suture. This, in some cases, is an easy procedure and it can be accomplished in most cases under ether anesthesia without very great difficulty, unless the intestines are greatly distended and the abdominal wall thereby made too tense for comfortable closure. Under such circumstances, it might be proper to reduce the tension by aspirating one or more of the intestinal coils, observing of course the greatest care not to infect the field of operation with intestinal contents.

Repair of Postoperative Ventral Hernia.—Ventral hernia is a not uncommon sequence to a laparotomy. The repair of such herniæ is frequently difficult and sometimes well-nigh impossible. The adoption of the principle of the musculo-aponeurotic overlap to the repair of these troublesome cases, however, has made them a promising field of effort for the surgeon, who may feel reasonably certain of securing permanently satisfactory results in most cases by the use of this method of overlapping flaps, which has given such brilliant results in the repair of large umbilical herniæ. For details of these operations the reader is referred to the proper chapter (Vol. IV, Chap. I).

Secondary Operation for Postoperative Abdominal Hemorrhage.—This must be dealt with by various secondary operations according to its situation and the needs of the individual case. Secondary hemorrhage from the pelvic cavity, following the removal of the uterus or the adnexa, requires prompt attention in order to save the patient. Re-opening of the abdominal wound should be done as soon as suspicion of serious hemorrhage arises, and the bleeding point should be sought for and tied. Temporary measures to prevent the further loss of blood, such as pressure over the abdominal aorta by the finger or by the use of Momberg's belt, may be of life-saving importance. Preliminary infusion of sterile normal salt solution or direct or indirect blood transfusion may be urgently called for. Prompt measures and well-directed effort are essential to success in these cases.

Postoperative hemorrhage into the alimentary tract after appendectomy, from the inverted and bleeding stump of the appendix, hemorrhage following gastroenterostomy, from the suture line of the anastomosis, hemorrhage into the cavity of the rectum following operations for hemorrhoids or tumor, or hemorrhage from a gastric ulcer or a duodenal ulcer after gastro-enterostomy may occur and demand a secondary operation for its relief. Some of these cases present the most complicated problems for the surgeon to solve, and success or failure depends largely on his skill and judgment.

Postoperative hemorrhage after appendectomy, as evidenced by tarry stools or by the presence of large quantities of blood, may call for the re-opening of the abdominal wound and securing the bleeding vessel in the appendiceal stump.

Postoperative hemorrhage after gastro-enterostomy from a bleeding vessel along the suture line of the anastomosis may be of sufficient importance to call for re-opening of the abdominal wound and searching for and ligating the bleeding vessel. Secondary hemorrhage from an ulcer of the stomach after gastro-enterostomy is of occasional occurrence and may call for operation. Rovsing recommends exploration of the interior of the stomach by means of gastroduodenoscopy and an attempt to locate the bleeding point and determine the necessity of a secondary operation. Bleeding into the interior of the stomach under the conditions just referred to may present a serious problem and one not always easy of solution. If, after the usual means are exhausted, the hemorrhage continues and threatens the patient's life, it may be proper to reopen the abdominal wound, make an incision through the anterior wall of the stomach, and endeavor to locate the bleeding ulcer and if possible excise it, or, in the case of a bleeding point in the mucosa, to pass a suture beneath it and try in this manner to control the loss of blood. Such exploratory gastrostomy is described elsewhere.

Hemorrhage from the duodenum, recurring after gastro-enterostomy, may demand pyloric exclusion by suture, excision, or other means suited to the exigencies of the case. Brewer recommends the use of a pressure band of aluminum passed around the pylorus.

Postoperative Operations for Abdominal Sepsis. Postoperative operations may be necessary for the revision of drainage of an existing abscess or for the drainage of residual intraperitoneal abscesses which may occur after operations for appendicitis with spreading suppurative peritonitis. As such abscesses may be in the pelvis, the left iliac or the subphrenic region, or in the right or left flank, or elsewhere, their location becomes necessary before they can be successfully approached and drained.

Secondary operations of various kinds are necessary under these circumstances and will be found described under the operations for subphrenic, perinephric, lumbar and intra-abdominal abscesses and will not be given detailed description here.

A personal case may best serve to illustrate the difficulties encountered in this class of cases. A patient was operated upon for gangrenous appendicitis with fibrinopurulent peritonitis. Her early convalescence was marked by the necessity of draining several pus collections in the neighborhood of the appendiceal field, and by slow and imperfect recovery. Several weeks after the primary operation she was seized with severe abdominal pain and constipation which was thought to denote an acute obstruction of the intestines. She recovered under the use of enemas and was sent home, only to return several weeks later with a painful mass in the left hypochondriac region, with fever and considerable depression. A diagnosis of secondary abdominal abscess was made, and a laparotomy was done over the site of the mass. This revealed a large abscess, well encapsulated by the omentum and the adjacent coils of small intestine and situated close to the region of the splenic flexure of the colon. Drainage in this case was entirely effectual, and rapid and complete recovery of health followed.

Secondary collections of pus in the immediate neighborhood of the stump of the appendix may sometimes be opened by thrusting the finger into the depths of the wound. For abscesses more remote from the field of wound drainage, however, secondary incision over the site of the collection is better surgery. Thus, for some of the pelvic abscesses following suppurative appendicitis, a low median incision may offer a safer and better approach than the wound, where considerable damage may unwittingly be inflicted.

Secondary abscesses in the culdesac of Douglas are sometimes drained through a vaginal incision or even through a rectal puncture.

Secondary laparotomy is sometimes necessary for the relief of a persistent sinus following incomplete operation for adherent cyst of the ovary. At the primary operation the patient's condition has allowed perhaps only partial excision of the cyst and stitching of the remainder of its wall around a drainage tube. Shrinkage then follows until finally only a small mass is left which will have to be removed at a secondary operation in order to close the sinus which is apt to persist.

Secondary Operations for Acute Pancreatitis.—When an anterior incision into the lesser sac of peritoneum affords insufficient drainage, a secondary opening through the left loin may be necessary. Such an incision, in fact, should generally be employed together with the anterior one at the time of the primary operation in cases of extensive fat necrosis, if the patient's condition will permit. As the drainage in these cases keeps up for a long time, the openings should be free and care taken to prevent any long-continued pressure of drainage tubes against adjacent vessels or hollow viscera in the neighborhood.

Secondary operation for late perforation of the stomach was necessary in a rather unique personal case of acute pancreatitis and was followed by recovery.

Secondary Operations for the Recovery of Foreign Bodies.—Secondary operations for the recovery of foreign bodies, pads, instruments, etc., left behind at operation, are still occasionally necessary.

Re-opening of the abdominal wound and removal of a sterile pad which lies just beneath the parietal peritoneum may be easily and quickly done. When, however, a pad is overlooked and remains in the depths of the wound after the removal of a gangrenous appendix, for example, persistent suppuration should give rise to the suspicion of such an accident and a search made for the offending foreign body. Forceps or scissors left behind at operation may become encapsulated and finally perforate into the intestine and be discharged or removed or they may lead to the most serious complications, such as secondary abscesses, obstruction, or various obscure postoperative conditions never fully understood until at some later operation the cause is at once revealed.

It will be seen, therefore, that the secondary operations for the removal of the various foreign bodies left behind at operation or lost subsequently in the abdominal cavity, the bladder, the gall-bladder, or the thoracic cavity, or in any deep wound cavity, are of various degrees of severity and extent. If the diagnosis can be made early, much suffering and danger may be avoided both to the patient and to the reputation of the surgeon.

The X-ray may be most useful in revealing the presence of lost instruments or drainage tubes, for example, whether in the chest, the abdomen, or elsewhere, and, by determining the exact location of the same, may simplify the operation for their removal.

The careful observance of the rules given elsewhere for the prevention of these unhappy accidents is the only way of ensuring their non-occurrence.

Secondary Operations for Postoperative Ileus. Postoperative ileus due to paresis of the intestinal wall alone or to kinks and adhesions with peristalsis insufficient to overcome it, may be a fatal complication following laparotomy. In the paralytic variety, it may be temporary, easily yielding to enemata and gastric lavage, or it may persist in spite of milder measures and seriously jeopardize the life of the patient. Under these conditions it is well to remember the good effects of a timely enterostomy.

This operation is a simple one and may often be a life-saving measure if not postponed too late. Under local anesthesia, the wound may be partly re-opened or a short new incision made, through which a coil of distended intestine may easily be reached and a tube inserted into it. Sometimes, if the presenting gut is very tense, it may be well to puncture it with a suitable needle to allow the escape of gas before inserting the tube. The tube is then invaginated into the lumen of the intestine by infolding the serous surfaces after Kader's method, to prevent soiling of the wound from leakage, and the intestinal contents are allowed to escape into a suitable vessel. Enterostomy should be done in these cases by the end of the third day or possibly as late as the fourth day of the obstruction, according to C. H. Mayo, to insure a successful outcome. The fifth day and later will often prove too late. If the patients survive for 24 hours after this procedure, many of them will recover. Some of them require no further operation, and any who may will soon permit of such an operation for the division of bands or straightening out of an adherent kinked loop of gut with comparative safety, by reason of their improved condition. If the opened loop of intestine should prove to be jejunum, it will be necessary to supply extra fluids by rectum. If the opening is low down in the ileum, sufficient nourishment is readily absorbed. The enterostomy fistula, as a rule, readily closes on the removal of the tube; if for any reason it should not, it may be easily repaired.

Where the obstruction is in the large bowel, an appendicostomy will serve to tide over a period of temporary obstruction, acting as a sort of safety valve for the escape of gas and fluids, or, if this is not feasible, the introduction of a tube into the cecum will serve equally well.

In cases of mechanical obstruction arising several days after a primary laparotomy for a suppurative appendicitis, early operation is imperative and frequently successful. Through a median incision a search is made for the obstructing band or adhesion. The band is divided or the adhesion separated, and circulation of the intestinal contents promptly restored.

Early recognition of this serious condition and early operation for its relief are the essentials for a successful outcome, granting, of course, that the case is in competent hands. The operation is described in detail elsewhere.

Secondary operations for the removal of an appendix which was not removed primarily become less frequent as the surgeon develops his sense of touch and the ability to find and remove the offending organ at the time of the original operation.

Abscesses about the buried stump of an appendix are sometimes the cause of profound sepsis, although such an abscess may be quite small and well encapsulated. In a case of this sort in which the appendix had been removed and the stump tied and buried, there was no mass to be felt and only by careful search was it uncovered and successfully drained.

Operation for Fecal Fistulæ.—Fecal fistulæ after operations upon the appendix, in which the organ has been removed, being, as a rule, deeply buried, are prone to close after the lapse of a few days or weeks. Where the appendix has not been removed, however, they generally persist, and removal of the appendix with closure of the stump is generally effectual. This operation presents some difficulties on account of numerous adhesions, but may be readily accomplished with ordinary care.

Fistulæ from pressure of the drainage tube on the wall of the gut are occasionally seen. These are repaired by exposure of the gut, paring of the edges, and proper suturing. Where the damage to the gut wall is too extensive, resection with lateral or end-to-end anastomosis may be called for.

Intestinal fistulæ, whether accidental or intentionally established, are to be treated by local suture or resection or by lateral anastomosis through a separate opening.

Operation for Gastric Fistulæ.—In the operation of gastrostomy, a fistula is established for the purpose of feeding the patient. If the mucous edges of such a fistula are sutured directly to the skin edges of the wound, as in the older operations, the fistula has no tendency to close. Under such conditions its closure is to be effected by exposure of the opening in the stomach, freeing it from the skin, paring off the excess of mucosa, and suturing the opening in the stomach by a double row of sutures and dropping the organ back into place. As all the modern operations of gastrostomy, such as Kader's, Witzel's and others, aim to establish a funnel-shaped or oblique tract bounded by peritoneal surfaces, the fistula tends to close rapidly upon the removal of the tube.

Operation for Duodenal Fistula.—As patients with duodenal fistulæ rapidly succumb to starvation from the rapid escape of stomach contents, and as repairs of such fistulæ by the usual methods have been proven ineffectual, these cases should be treated by pyloric occlusion and posterior gastro-enterostomy, as first suggested by Berg in 1903.

Moynihan describes at length the treatment of these rare cases.

Operation for Biliary Fistulæ.—In the older methods of cholecystostomy, where the edges of the opening in the gall-bladder were stitched to the skin, these fistulæ were of much more frequent occurrence. The modern method of draining the gall-bladder by means of a tube invaginated into the opening in such manner as to bring the peritoneal surfaces into contact furnishes few cases calling for treatment.

Occasionally an overlooked stone or a pledget of gauze or cotton keeps open a fistula which persists until the stone or foreign body is removed.

Cases of hydrops of the gall-bladder, treated by cholecystostomy, furnish a small quota of cases of persistent fistula. These are best treated by removal of the gall-bladder when such an operation is practical.

Repair of biliary fistulæ due to error in technic in the primary drainage operation may be easily accomplished by paring the edges and careful suture. All these operations are described in detail elsewhere.

Secondary operations for the relief of the so-called "vicious circle" following gastro-enterostomy may consist in the revision of the original operation, closing the old anastomosis and making a new one at a more dependent situation, or in performing a pyloric occlusion, or doing an entero-anastomosis between the afferent and efferent loops of the jejunum.

Operation for Ureteral Fistulæ. Accidental wounds of the ureter during the operation of hysterectomy or excision of carcinoma of the rectum, etc., may occasionally be followed by ureteral fistulæ. The various operations for the plastic repair of fistulæ of this character, together with the operation of nephrectomy or implantation of the ureters into the rectum, etc., are described at length in the chapter devoted to the consideration of these subjects.

Operation for Vesical Fistulæ.—Fistulæ of the bladder opening upon the surface of the abdomen are generally easily closed by paring the edges and proper suture. The operations for rectovesical, vesicovaginal, and vesico-uretero-uterovaginal fistulæ are elaborate procedures described at length elsewhere.

Secondary Operations upon the Kidney.—After nephrotomy for stone or other condition of the kidney, severe hemorrhage may occur and necessitate prompt measures for its relief. Secondary nephrectomy is often necessary under these conditions if re-suture of the kidney fails to control the bleeding. As the patient's condition is often very poor under these circumstances, the question of using paravertebral or spinal anesthesia may arise.

Secondary nephrectomy, after primary nephrotomy for drainage in pyonephrosis, often presents considerable difficulty, both on account of the wretched condition of the patient and the local conditions resulting from prolonged suppuration in and around the kidney. The technic of the various procedures is gone into thoroughly in the chapter devoted to the consideration of this subject.

Secondary nephrectomy for division of the ureter not recognized at the time of primary operation may occasionally be necessary.

Implantation of the injured ureter into the bladder may sometimes be feasible as a secondary operation.

POSTOPERATIVE OPERATIONS UPON THE EXTREMITIES

Secondary operations for postoperative hemorrhage, sepsis, or obstruction to circulation, follow the general rules already given. Hemorrhage is to be controlled by pressure or ligation; infection is to be dealt with by relaxing tension and providing free drainage, either by revision of the wound, by the making of extra incisions, or, in extreme cases, by amputation of the extremity.

Re-suture of infected wounds which have become clean, granulating wounds is frequently advisable and presents no special difficulties.

The removal of foreign bodies, drainage tubes, etc., after operations in the axilla and elsewhere may occasionally be necessary.

Revision of drainage in compound fractures following failure to secure relative asepsis, or to maintain it, consists generally in placing extra incisions to favor freer drainage, or, in the event of their failure and the development of general sepsis, amputation may be called for.

Secondary operations for the removal of metallic plates used to secure end-to-end apposition in the treatment of simple fracture of the long bones may be necessary for various reasons not to be discussed here. The operation, often a late secondary procedure, consists in removing the loosened plate through a proper incision and presents no special difficulty.

Secondary operations such as autoplastic bone grafting for non-union, following plating in simple fractures, will be described elsewhere.

Secondary operation of ligation of the internal iliac artery for uncontrollable secondary hemorrhage in the gluteal region has been occasionally necessary.

Patching the femoral vein, after Carrel's method, and repair of loss of substance in the femoral artery, by using a portion of the saphenous vein to fill the gap, as well as the operations for the suture of wounded vessels which for various reasons it may be best not to ligate, are described at length in another chapter. Secondary suture of nerves accidentally injured at operation is also described elsewhere.

Secondary plastic operations for the relief of contractures following incisions for the drainage of abscesses on the flexor side of joints follow the rules already given, each case to be treated upon its own indications.

Secondary amputation following division of the popliteal artery in excision of the knee-joint is occasionally necessary, as it may be after accidental wounds and ligation of the common femoral vessels during the operation for the radical cure of inguinal hernia. The development of arterial suture and vessel grafting and patching opens up a broad field for conservative work in some of these cases.

CHAPTER IV

BONE AND JOINT SURGERY

FRED HOUDLETTE ALBEE

INTRODUCTION

The past few years has been a most eventful period in the development of bone and joint surgery. An important feature of this advancement has been the introduction of the electric motor, with its various attachments, as a means of moulding and shaping bone accurately and speedily in its widening field of application. I have found this instrument with my attachments indispensable in a large proportion of bone work, such as applied in:

1. Pott's disease.
2. The shaping of the dowel and inlay graft for ununited fractures.
3. The trimming and proper shaping of fragments to insure better position and approximation.
4. The bone-wedge graft for the correction of deformity and faulty balance.
5. The accurate shaping of bone to fill defects, congenital or acquired.
6. All purposes of drilling bone.

In all of the above operations the ease and accuracy of application of the motor outfit far supersede all hand instruments for doing similar work.

POTT'S DISEASE

HYGIENIC TREATMENT

It is always essential in this condition, as well as in all tuberculous cases, that the patient be placed under the best hygienic surroundings, and that a strict régime of life be maintained suitable for tuberculous patients in general, the chief essentials being *fresh air, sunlight, forced feeding,* and *general rest.*

MECHANICAL TREATMENT

In order to better understand the fundamental mechanical principle involved in the treatment of tuberculosis of the spine, it must be appreciated that the disease is wholly in the vertebral bodies, and that the progress of the condition is that of a crushing and destruction of this part of the vertebra. This is caused not only by the *superincumbent weight* of the body above the point of disease, but also in a large measure by *muscle spasm* and constant *respiratory motion*. The last factor is more potent in the dorsal region, but its influence is considerable in any region of the spine.

From this standpoint, it is evident that the mechanical conditions for effective splint support are unfavorable in any region of the spine, and it is apparent, also, that the conditions are more favorable in some parts than in others, i. e., the splint is more efficient in the lower dorsal and upper lumbar regions on account of the focus of disease being in the central portion of the spine, thus affording a maximum of leverage above and below.

The opposite condition is found in the upper dorsal region, where the leverage above is short and the superincumbent weight of head and shoulders, together with the physiological curve, favors an anteroposterior kyphosis. The poor leverage below the focus of disease is even more marked in the last few lumbar vertebræ.

With the disease in these regions, horizontal fixation is the most efficient, conservative treatment.

Horizontal Fixation.—An effective and convenient horizontal support is the Bradford-Whitman gas pipe frame. This is a rectangular frame, a foot and a half longer than the patient, and in width equal to the intra-axillary distance. Over this frame a cover of strong canvas is stretched by means of corset laces on its under surface. The canvas can be made in 2 sections with an interval between to allow for the bed-pan. Two felt pads about 7 in. long and 3/4 in. thick are sewed to the canvas to prevent excoriation by raising tip of kyphosis of pressure. The patient is held in place by a front piece or apron, secured to the sides of the frame by straps and buckles. As soon as he becomes accustomed to the restraint, the hyperextension of the spine is increased from time to time by bending the frame upward beneath the kyphos. This tends to separate the vertebral bodies, relieving them partially for the time being from friction and pressure.

The patient is kept constantly upon this frame, the clothing, in cases of children, being made large enough to include the apparatus, thus assuring better fixation. The patient should be removed once a day, inspected, bathed with alcohol, and powdered with talcum, or stearate of zinc, etc., after which the apparatus is reapplied.

In disease of the cervical region and acute cases of the upper dorsal traction by means of a Sayre halter and sling is desirable to give greater fixation and hyperextension. This halter is attached to a cross-bar at the upper end of the frame.

Likewise, in cases of disease of the last lumbar vertebra, traction is made on the limbs. In very acute cases a light plaster-of-Paris jacket or back-brace may be necessary to supplement the fixation of the frame for the relief of symptoms.

Pain and discomfort usually disappear within a few days after the patient is fixed on the frame. The treatment of all acute cases, if conservative treatment is to be followed, should be begun by the immobilization of the patient on the horizontal frame. This is not an absolute fixation, but it is the most effective of any of the methods of conservative treatment, in that, so long as respiration continues, perfect fixation is not possible by external means. But there are individual cases where this does not apply, and pain persists in spite of the recumbent treatment.

Recumbent fixation, however, is not a complete method in that sooner or later some ambulatory fixation becomes necessary, in the form of either plaster-of-Paris jacket or a brace.

The duration of the frame treatment varies from 6 months to 2 years. The indications for discontinuance are relief of all symptoms and apparent arrest of the local disease, as indicated by physical examination and X-ray findings, also the increased freedom of motion and restlessness of the patient when removed from the frame for sponging, evidently fretful from long restricted confinement. It becomes advisable at this stage to change to ambulatory support.

Ambulatory Support. Ambulatory supports are of 2 types, the plaster-of-Paris jacket and the steel brace. The selection of either of these depends upon a number of factors, chiefly (1) the individual experience of the surgeon, (2) the coöperative inclination and intelligence of the family, (3) the age of the patient. The plaster jacket is best adapted for use in children of the poor and ignorant class, being less likely to be tampered with. As a rule, the brace is best suited to the adult and to children of intelligent families.

THE PLASTER-OF-PARIS JACKET. All that can be expected of the plaster jacket is to hold the spine in general alignment. It is a simple splint to the whole spine and only partially fixes the individual segments. Its efficiency depends upon the accurate and smooth application over the body's irregularities, and upon its leverage above and below the diseased focus. It should be applied with the spine held in the most favorable hyperextended position, which, as a rule, is obtained by the Sayre suspension apparatus.

After the skin is prepared by bathing with alcohol and dusting with talcum powder, a seamless jersey shirt or stockinette is applied. This should be of sufficient length to allow for its being turned up to form an outer cover to the jacket. The patient is then placed upon a stool, and the halter of a Sayre suspension apparatus adjusted about the head. The arms are extended above the head and grasp the suspending straps on either side. The patient is then suspended by sufficient traction to raise the heels off the stool. The anterior spines and the crests of ilia and sternum are protected by piano felting.

The spinous processes of the kyphosis are protected by a strip of saddler's felt placed on either side to protect them from chafing, and to allow greater pressure and fixation at the point of disease. In adolescent and adult females the breasts are protected by cotton, which may be removed later if there is undue pressure. No dinner pad is used except in thin adults.

THE PLASTER BANDAGE.—The commercial, ready-made plaster-of-Paris bandage is very poor. To prepare suitable bandages smooth, moderately close meshed, unsized crinoline is torn in proper widths, usually 6 yd. long and 5 in. wide; all loose threads are removed from the edges, and the crinoline is then rolled loosely, so as to facilitate handling. A heap of the best and dryest dental plaster is placed on a table, the crinoline is drawn through the plaster, and the meshes are filled by rubbing the plaster in thoroughly with the hand as the bandage is being rolled loosely. The finished rolls are wrapped in tissue, placed in a tightly covered tin can and kept in a dry place. If the plaster bandages are too slow in setting, they should be placed in an oven of only moderate temperature, and thoroughly dried out for several hours, when they are made ready for use again. The bandages are placed on end in a pail of water, the temperature of which should vary with the dryness of the plaster and the length of time required to apply each individual splint. Since the temperature of the water influences the setting of the plaster, warm water should be used in small and simple splints, while cooler water is indicated for larger and more complicated ones in order to avoid lamination. No salt should be used to hasten the setting, as it produces brittleness. The bandage should remain under water until bubbles cease to rise. The surplus water is then squeezed out by seizing an end of the bandage in each hand and wringing until no water drips. The loose threads are then removed from the ends, and the bandage is ready.

While the jacket is being applied, an assistant sits in front, holding the patient's thighs to prevent swaying and rotation. A second assistant, standing to the side, rubs each layer of plaster bandage thoroughly as the turns are made by the surgeon, who stands at the back of the patient, and also rubs in each layer thoroughly.

Care should be taken that the jacket is made of uniform thickness throughout, 3/16 to ¼ in. It should extend above the sternal notch and below the anterior spines sufficiently to afford plenty of length for trimming.

Before the plaster sets it is moulded so as to increase its leverage, and trimmed.

The patient should be placed in a recumbent position for not less than 1 hour after the application of the jacket, in order to insure sufficient firmness before strain is brought to bear upon it by assuming the erect posture.

If the disease is above the ninth dorsal vertebra, a jury-mast or head support, incorporated in the plaster, is necessary to lengthen the leverage above the point of disease and aid in holding the spine in hyperextension.

MODIFICATIONS OF JACKET.—The jacket may be changed to meet the various individual requirements—for instance, the plaster may be carried over the shoulders to secure more efficient hyperextension, or the head may be included as a substitute for the jury-mast. One or both thighs may be included for acute and painful disease low down or for psoas spasm. A very efficient method is that of the modified Calot, where a corrective jacket is worn in recumbency from 1 to 2 years, followed by the *military* style for all cases below the ninth dorsal vertebra, and the so-called *grand* style for all cases above the ninth dorsal vertebra. In the hands of the author it has been found preferable to use the American plaster-of-Paris roll in applying this jacket instead of the technic of application advised by Calot.

In applying the military and grand types of the Calot, the Sayre suspension apparatus is used, excepting the leather halter. As a substitute, portions of 3 in. muslin bandages have been adjusted about the chin and occiput, and held by means of large safety-pins, so as to be easily removed. The military jacket is applied in a way very similar to the ordinary jacket, except that the shoulders are padded and included in the plaster with a military collar above. The grand differs in that the head is hyperextended and held by including the chin and occiput.

In the case of either type of jacket, a square window is made over the kyphos, sufficiently large to admit a layer of thick felt with a hole in the center to relieve pressure on the spinous processes of the kyphos. This is placed in contact with the stockinette, and the corrective force is established by forcing in layers of cotton, after which the square of plaster removed is fastened in place again, under pressure, by a few layers of plaster-of-Paris bandage. A large triangular window, with its apex upward, is made in the front of the jacket in such a position as to allow the spine to be forced forward at the level of the kyphosis. A constant corrective pressure is maintained by removing the plaster window and adding to the cotton padding at intervals of 2 weeks, as the kyphosis recedes.

It should be appreciated, however, that the correction thus obtained is most difficult to maintain, owing to an irreparable loss of substance in the diseased vertebral bodies, and also as there is so little osteogenesis.

Mechanical support can never be removed without great apprehension of a relapse of the deformity or of the disease, and should be discarded with the greatest conservatism. It is in this particular, among others, that the operative treatment is so much to be preferred, in that bone support is quickly and directly supplied.

THE SPINAL BRACE.—The other type of spinal support recommended is the spinal brace of Dr. C. F. Taylor, which consists of 2 steel parallel uprights, ½ in. wide, gauge 8 to 12, one on each side of the spinous processes extending from buttocks to the seventh cervical vertebra. Pressure pads of ground cork or soft leather are adjusted on the under surface of the uprights. These allow greater pressure for fixation and correction of deformity at what is the fulcrum of the brace lever when the upper and lower ends are fixed to the shoulders and pelvis. To the lower ends of these uprights is fastened a pelvic band of sheet steel, 1½ to 2 in. wide, with average gauge 18, and reaching from one iliac spine to the other. Opposite the second dorsal vertebra 2 shoulder pieces of lighter metal extend over the shoulders to about the middle of the clavicle. These are padded and from their ends padded shoulder-straps are continued around and under the arms, and then buckled to the uprights at about the level of the angle of the scapula. Additional fixation is had by applying an apron covering the abdomen and fastened below, by a strap sewed to its lower border, to buckles at the ends of the pelvic band. The upper border is similarly arranged with straps and buckle to the uprights at a level with the axilla.

To measure for the brace have the child face down on a firm, flat surface. A lead tape is then applied along the spine over the lateral masses and an exact outline is thus transferred to a piece of cardboard, and trimmed with scissors ready to shape the uprights by. Modifications and changes can be made to adapt this brace to special indications, but that shown in the accompanying illustration is the one used in the average case.

In cases where the disease is above the ninth dorsal vertebra, a hard rubber chin cup or jury-mast attachment to the brace is necessary.

OPERATIVE TREATMENT

Technic.—The technic of the author's (Albee) operation for Pott's disease is as follows: With the patient in the ventral position, the tips of the spinous processes are reached by a curved incision and turning up of a flap of skin and subcutaneous tissues. With a scalpel the periosteal tips of the spinous processes are split in the center, also the supraspinous ligament, leaving each part of it attached to the spinous processes. The interspinous ligaments are next split into approximately equal parts to a depth of about ½ in., varying with the age and the size of the patient, without disturbing their attachments to the spinous process. Very little hemorrhage results, because only dense ligamentous tissues have been incised, which is in considerable contrast to the hemorrhage resulting from the separation of the muscles from the spinous processes in a deeper operation, such as a laminectomy. With a thin, sharp chisel, or author's osteotome and mallet, each process is split longitudinally into equal parts for a depth of about ½ in., care being taken that green-stick fractures are produced on one and the same side of all the spinous processes. The unbroken halves preserve intact the leverage of these processes. A separation of the halves of each spinous process produces a gutter into which the transplant is later placed. (See Fig. 1.) In all cases the full thickness of the tibial cortex is included with the periosteum, endosteum, and attached marrow substance, thus producing a transplant with approximately a rectangular cross-section. It has been found advisable for bone grafts for all purposes to include periosteum and endosteum, as it is through these media that cortical bone largely receives its nourishment. Thus, the graft approximates a complete organic structure, with its normal means of distributing nourishment, and the early establishment of blood supply is enhanced.

A graft of this thickness necessitates producing a full fracture of half of the spinous process and setting it over laterally in order to place it deep enough to be well covered with the above-mentioned ligaments. It is important that the spinous processes be split in situ with all the ligamentous and muscular insertions undisturbed, as in this way none of the natural supports of the spine are taken away and the ligaments afford, by means of strong ligatures, an excellent medium for firmly fixing the bone splint in place.

The depth to which the spinous processes are split varies with the age and size of the patient and the amount of pressure atrophy from former apparatus, which may so reduce the spinous processes as to present mere tubercles on the posterior aspect of the neural arches and in certain instances make it possible to split in depth only 3/16 to 1/4 in. This, however, affords good bone contacts and, as the graft is embedded into longer spinous processes at either end, it affords the usual efficient fixation. A hot saline pack is placed over the back wound until the bone insert is obtained.

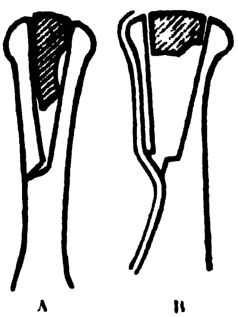

Fig. 1. Diagram Illustrating Graft in Situ in Tip of Spinous Process. A is straight or moulded graft in place. (See also Figs. 3 and 4.) The graft should always be placed in this manner when possible (i.e., broader diameter antero-posterior). B is a graft bent into position with its wider diameter laterally (see also Fig. 2), thus necessitating one of the halves of the spinous processes being broken completely and pushed sidewise so as to produce a gutter of sufficient width to receive the inlay. This many times is also necessary when inserting the graft as illustrated in A. (Albee's technic.)

With the patient still in the ventral position, the leg is flexed on the thigh and an incision over and down to the crest of the tibia is made. The fascia and subcutaneous tissues are carefully separated from the periosteum of the anterior internal flat surface of the tibia. From its crest and anterior internal aspect a strip of the tibia is removed with a motor saw, which affords a very rapid and exact method of securing the graft and is used exclusively for this purpose. The length of graft varies according to the number of vertebræ to be spanned, i. e. all those diseased and 2 healthy ones on each side, if in the dorsal region, and 1 on each side if in the lumbar region. (See Figs. 2 and 3.) Its breadth varies from 1/4 to 5/8 in. and its thickness from 3/16 to 3/8 in., according to the size of the patient. The graft is inserted between the halves of the interspinous ligaments and the spinous processes with its edge anterior or innermost, and its cut side or marrow side in contact with the unbroken halves of the spinous processes. It is held firmly in position by interrupted sutures of heavy or medium kangaroo tendon, which are passed through the supraspinous ligament and posterior edges of the halves of the interspinous ligaments near the tips of the spinous processes, beginning at the center of the graft. The ligaments are then drawn over the insert posteriorly by tense sutures placed closely together. Before tying the last sutures, the posterior corners of the ends of the graft are removed by the rongeur, and these fragments of bone, with others, are cut into small pieces and placed under and about each end of the graft; the ends of the graft are then drawn down and sutures tied. This is important as it furnishes multiple foci for a rapid proliferation of bone, as, according to Macewen, the smaller the graft the greater the relative bone growth. If there is a moderate kyphosis of short duration, it is entirely obliterated, while any kyphosis of a few years or less duration becomes much diminished, either at the time of operation or during the first few days after, from the corrective effect of the lateral tension of the graft.

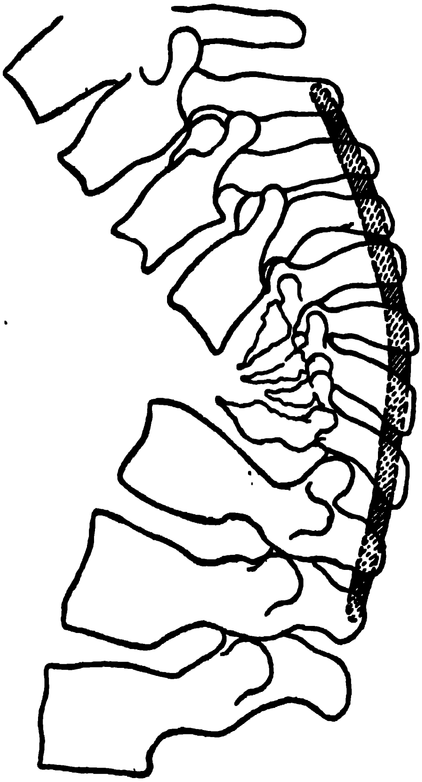

FIG. 2.—DESTRUCTION OF FOUR DORSOVERTEBRAL BODIES. The bone graft which has been bent into tips of spinous processes is holding spine in precisely the same alignment as when it was inserted 18 months before. (Drawing from skiagram.)

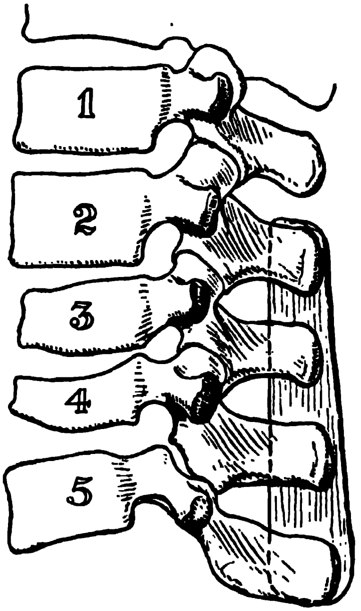

FIG. 3.—LATERAL VIEW OF LUMBAR SPINE WITH GRAFT FROM TIBIA INLAID INTO SPINOUS PROCESSES OF 2ND, 3RD, 4TH, AND 5TH LUMBAR VERTEBRÆ. (Drawings from skiagram.)

The sequence of the technic as thus outlined is important because, by preparing the back wound first and packing it with a hot saline compress, we secure hemostasis and control the blood-clot about the graft, a condition to be desired. A certain amount of blood-clot is desired as it facilitates bone growth. The serous oozing which takes place from the several tissues furnishes a good culture medium for the bone graft. This same medium, blood, serum, or plasma, has been sought in preparing tissue cultures for the microscopical study of cellular bone growth. Cold abscesses about the spinous processes are rare, but when found do not usually interfere with satisfactory union.

Where a kyphosis is too great for implanting a straight splint properly in place in the spinous processes, the approximate contour of the knuckle is obtained by bending a silver probe over the tips of the spinous processes. The curved probe is then laid upon the anterior-internal aspect of the tibia as a pattern and a graft of the desired shape, width and thickness is outlined in the periosteum with a scalpel. The graft thus outlined is then removed with the motor saw. (See Fig. 4.) The graft, however, is usually straighter than the kyphosis and the spine is straightened and drawn to the bone splint by means of the heavy ligatures.

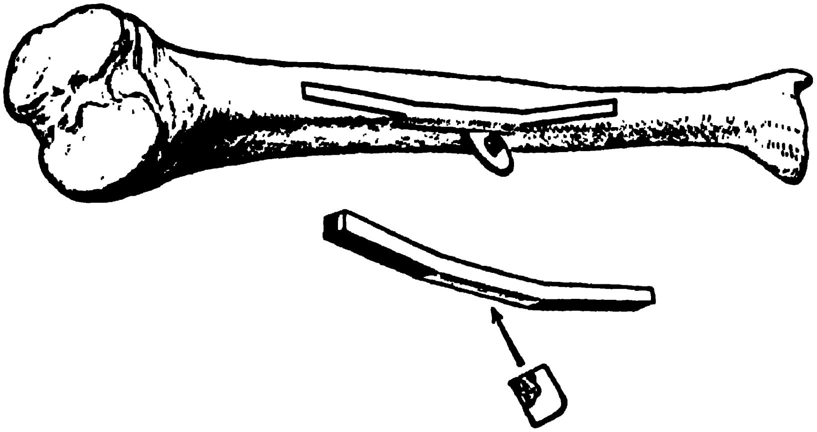

FIG. 4.—DRAWINGS OF TIBIA AND MOULDED GRAFT BEING REMOVED BY CIRCULAR SAW FROM ANTERIOR-INTERNAL SURFACE FOR INSERTION INTO A MODERATE KYPHOSIS. Small drawings indicate cross-section of graft and its contour after removal.

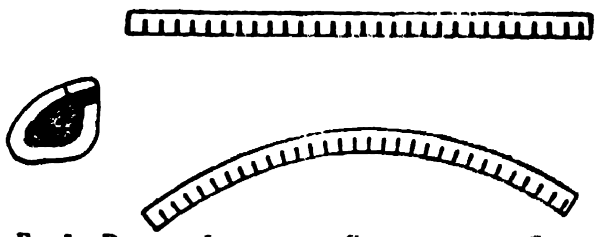

FIG. 5.—DRAWING ILLUSTRATING CROSS-SECTION OF SPINAL GRAFT FROM CREST OF TIBIA AND LONGITUDINAL-SECTION SHOWING SAW CUTS ON MARROW SIDE ALLOWING GRAFT TO BEND INTO A KYPHOSIS TOO LARGE FOR A MOULDED GRAFT.

When the deformity is too great even for this method, the graft is placed with its wider diameter in a lateral rather than anterior-posterior plane (see Fig. 1, B) and then bent into place between the halves of the spinous processes and held with heavy kangaroo tendon, as above indicated. This is accomplished by making numerous saw cuts ½ to ⅔ the way through. These cuts not only shape the graft to the kyphos, but also favor a rapid establishment of blood supply and the throwing out of bone callus from the graft itself. The cross cuts, ⅛ to ⅜ in. from each other, are always made on the marrow side. (See Fig. 5.) The transplants vary in size from 4 to 7½ in. in length; ¼ to ½ in. in width;

¼ to ⅜ in. in thickness. Care is taken that the insert has some bone marrow. The importance of this has been pointed out by several German investigators. Before placing the unbent graft in its bed, its periosteum is incised in many places, so as to allow the underlying osteogenetic cells exit for proliferation, and also to furnish an entrance of blood supply to the graft. The graft, firmly embedded under tension in the spinous processes and the dense intraspinous ligaments, affords immediate and excellent fixation of those vertebræ involved even before union takes place. This is confirmed by the immediate disappearance of pain in adults, and of pain and night cries in children.

The environment of the spinal insert is most favorable; it is not only wedged into healthy spinous processes, which are less than ¾ in. apart, but is also surrounded throughout its entire extent by ligamentous tissue which is normally attached to bone. The conditions are favorable for a rapid establishment of an Haversian blood supply from the spinous processes to the graft. I believe that the fact that the spinal graft rarely shows any evidence of disintegration or absorption is explained in this way. Where the kyphosis is marked and angular, green-stick fractures of both halves of the prominent spinous processes are produced with the osteotome, and their tips turned in laterally and sutured in contact with the posterior surface of the transplant. This produces additional bone contact for graft and reduces the kyphosis by so much.

Postoperative Treatment.—Although it is known from experimental work that the graft becomes united by bone union in 4 weeks, nevertheless the patient is confined in a recumbent position on a fracture bed for 6 to 8 weeks, after which he is allowed to walk about without apparatus for a part of the day. Where a straight graft of sufficient length is used, there is no necessity for a plaster jacket or support. In dorsal cases, where a deformity has developed, necessitating pronounced bending of the graft, a spinal support may be advisable for a few months. It should be emphasized that these cases should be under the observation of a surgeon experienced in this line of work throughout their whole convalescence.

The relief of pain and acute symptoms is most satisfactory. External spinal supports, as plaster jackets and braces, should always be avoided, not only on account of their interference with the normal function of respiration, but also on account of their injurious effect on the graft itself, not only from pressure, but in interfering with its function and the stimulus derived there from. This is realized by every investigator of bone work.

Indications for Operative Treatment.—Fixation by the bone graft is indicated in all cases, at all ages, where pain or muscle spasm demands immobilization of the diseased vertebræ, and the earlier the operation the more favorable the prognosis. It is indicated for the prevention and correction of increasing deformity, and is even more urgent in the presence of complicating conditions, such as psoas spasm, cold abscess, or paraplegia. The only special *contra-indication* is the inability to secure a clean field of operation. This, however, is rare, as cold abscesses seldom point in or invade the region of the spinous processes. Uninfected cold abscesses between the spinous processes have not interfered with primary union.

Prognosis. The prognosis in all operated cases is most favorable as to relief of all symptoms and decrease of deformity. Correction of deformity is most favorable in cases operated early and cases of longer duration where the kyphosis is sharply angular or presents a considerable amount of motion. In the 200 personal cases operated a surprising amount of respiratory mobility was noted in the center of the kyphosis in all the early cases, and in a considerable percentage of cases of even 4 to 6 years' duration. These observations were made after the spinous processes were exposed, and while the patient was lying prone on a firm operating table, breathing quietly under an anesthetic. Under these conditions, slight motion only could be detected between the healthy vertebræ on either side of the kyphosis. The undoubted reason for this increased motion is the loss of support due to the destruction and absorption of the diseased vertebral bodies, leaving only the lateral masses with their facets and the spinous processes to support the column.

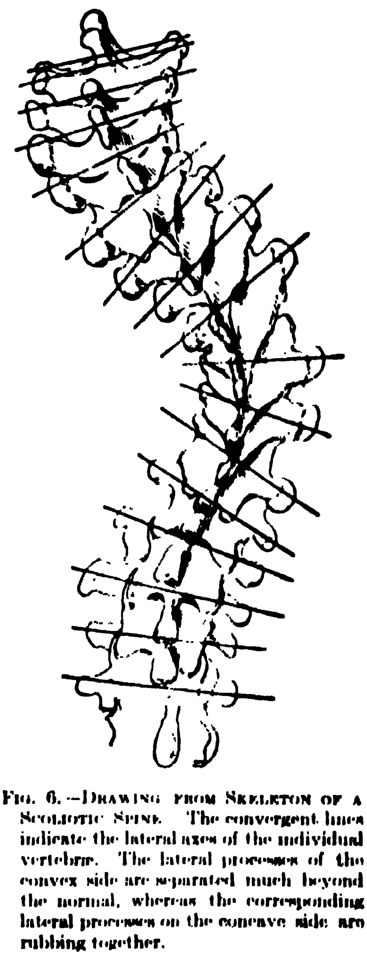

FIG. 6.—DRAWING FROM SKELETON OF A SCOLIOTIC SPINE. The convergent lines indicate the lateral axes of the individual vertebræ. The lateral processes of the convex side are separated much beyond the normal, whereas the corresponding lateral processes on the concave side are rubbing together.

When the lateral spinal deviation is corrected the lateral processes on the convex side approach their normal distance apart; if a graft is then inserted into their tips a relapse of the lateral curvature is thus prevented.

PARALYTIC SCOLIOSIS

In cases of very flexible paralytic scoliosis, uncontrollable when the trunk is in the vertical position, where there are sharp angular curves, a graft has been implanted in the tips of the lateral processes of the convex side (see Fig. 6), at the apex of the sharpest curve, after straightening, in a manner similar to that employed in applying the graft (Albee) to Pott's disease.

The treatment of these cases, otherwise impossible to control by external supports, such as plaster jackets, corsets, or braces, has been much facilitated. The graft, however, acts only as an adjunct to external supports.

SPINA BIFIDA

In cases of spina bifida, where the meningocele has been controlled, and a large deficiency of vertebral bone exists, together with weakness, as evidenced by lordosis or other deformity, the bone graft offers an excellent means for strengthening the spine weakened from the congenital bone deficiency.

Operative Technic.—The technic (Albee) is somewhat similar to that adopted in Pott's disease. Modification is necessary on account of the absence of spinous processes and parts of neural arches. The spinous processes above the cleft and the lateral masses of the last lumbar vertebra and the first part of the sacrum are reached from each side by 2 curved skin incisions, as it is undesirable to interfere with the nerve tissue which is usually involved in the cicatrix following the operative reduction of the meningocele. The second spinous process above the cleft is split longitudinally and a green-stick fracture produced in each half. The first spinous process above the cleft is denuded of its muscular and ligamentous attachments and both sides freshened. Below the cleft the lateral masses of the fifth lumbar vertebra, or the congenitally deformed stumps of the neural arches, if sufficiently prominent, and the first segment of the sacrum, which is usually congenitally hypertrophied, are split with the osteotome, and the halves separated to receive the lower ends of the two grafts.

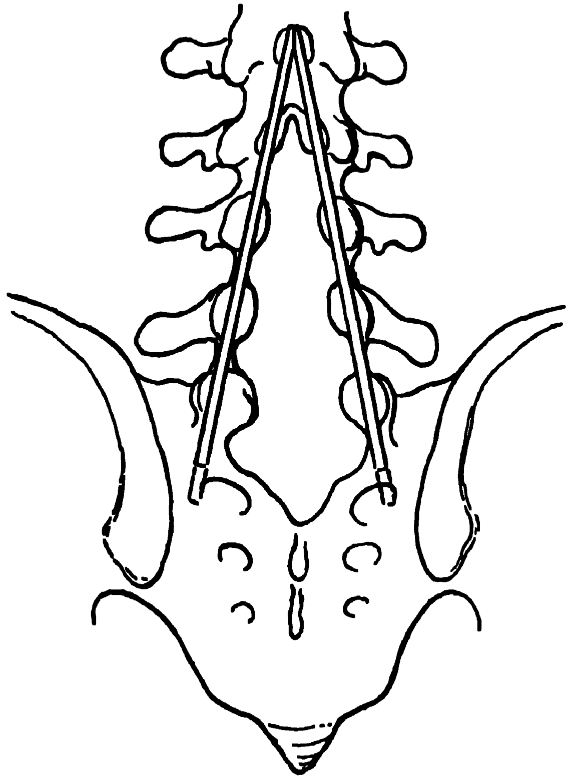

Fig. 7.—Diagram Showing Albee's Use of Tibial Bone Grafts in Straightening and Supporting a Bifid Spine.

The wounds are packed with a saline compress and the two grafts are prepared and removed from the crest of the tibia, long enough to reach from the split spines above to the sacrum below. The upper ends are beveled, so that, when these beveled surfaces come together, the grafts form an acute angle, like an inverted V. The grafts are placed at this angle in the beds prepared for them, and held firmly in place at their bony contacts by drawing the split ligaments over them with interrupted sutures of medium kangaroo tendon. (See Fig. 7.) Skin wounds are closed, and the patient placed on a fracture bed for 6 weeks.

FRACTURE OF THE SPINE

In persistent cases of non-union following fracture of the spine, presenting pain, disability and increasing deformity, the bone graft is indicated, and should be inserted as for Pott's disease.

It is also indicated in fresh fracture of the spine and spondylitis traumatica (Kümmell's disease) and neuropathic spine (Charcot), where, on account of a rarefying osteitis, crushing of the vertebral bodies and increasing deformity are likely to produce cord compression.

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

The prognosis of tuberculosis of the sacro-iliac joint, when treated by conservative methods, is most unfavorable. Tubby states that 7.9 per cent. only recovered in the moist type when treated by conservative means, in a series of 38 cases. As in the case of bone and joint tuberculosis elsewhere, the prognosis is more favorable in children than in adults. This joint is most unfavorable for external splint fixation, largely on account of its anatomical architecture. Its joint surfaces are oblique, inclining from above downward, forward, and outward. Its strength is wholly dependent upon its ligaments. It furnishes no chance for leverage control.

The sacrum, on account of its extreme inclination, is at the disadvantage of being an inverted key to an arch.

Conservative treatment is best carried out by the double Thomas hip splint or the double plaster-of-Paris spica in conjunction with recumbency during the acute stage.

Internal bone fixation offers the only satisfactory means of immobilization, on account of the above-mentioned anatomical conformation, together with the very powerful muscle action which affects this joint.

Operative Technic.—The following technic has been devised by the author (Albee) for using the bone graft in this condition, and has furnished most satisfactory results: The posterior-superior spine and the wing of the ilium and first spinous process of the sacrum are reached by a curved incision. The posterior border of the wing of the ilium and the spinous process are split, with their attached ligaments, by a thin osteotome, forming a gutter to receive the ends of the graft. If practical, a surface on the sacrum is denuded to furnish additional contact with the graft. The wound is packed with a saline compress and, with the patient still in the prone position, the leg is flexed and a graft of sufficient length is removed from the crest of the tibia by the motor saw, as described in the use of the bone-graft in Pott's disease. The width of the graft should be 3 times the thickness of the cortex. The thickness should include the whole cortex, periosteum, endosteum, and a small amount of the adhering marrow. The graft is placed in its prepared bed, and the ligaments drawn over it by interrupted sutures of medium kangaroo tendon. (See Fig. 8.) The skin wound is closed and the patient is placed on the back in a fracture bed, for a period of not less than 5 weeks. There should be no necessity of further mechanical treatment.

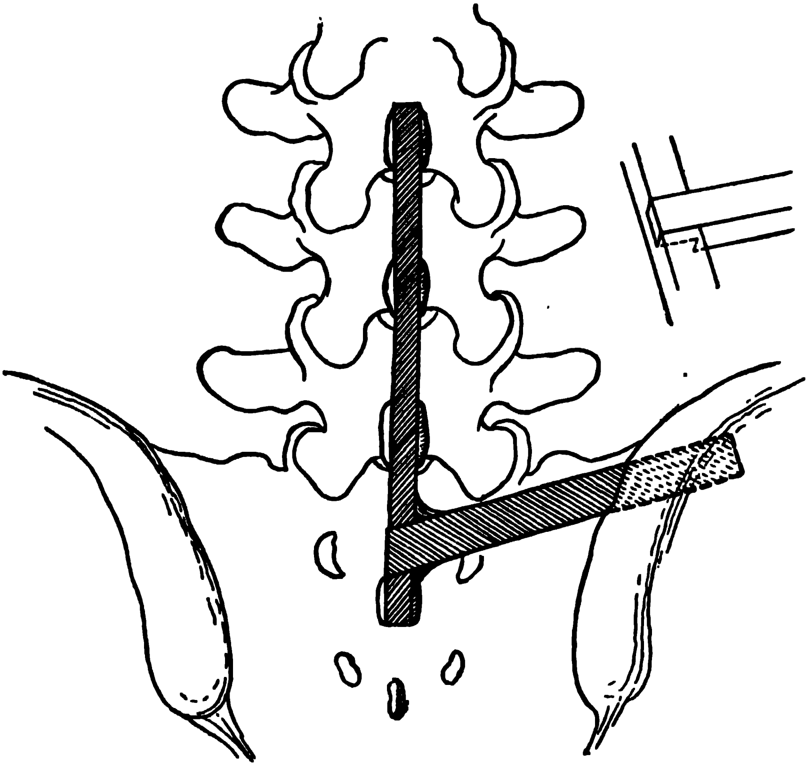

FIG. 8.—DRAWING OF SKIAGRAM INDICATING TIBIAL GRAFTS INSERTED FOR LUMBAR, SACRAL AND SACRO-ILIAC TUBERCULOUS OSTEITIS. The graft in lumbar spine was inserted into spinous processes by usual technic. The sacro-iliac graft was mortised into the first at one end (see small diagram in upper right corner), while the other end being wedge-shaped was inserted into split posterior wing of ilium. (Albee's technic.)

DISLOCATION OF THE SACRO-ILIAC JOINT

Dislocation at this joint is a most rare condition, but if met with, reduction under general anesthesia should be resorted to. This is best accomplished by hyperextending the spine, making traction upon the leg of the affected side and by manual manipulation of the ilium into a proper relationship with the rest of the pelvis. Postoperative dressings should consist of a well-moulded plaster-of-Paris spica extending from the axilla to the knee, with the lumbar spine in hyperextension. The spica should be worn 10 to 12 weeks.

SACRO-ILIAC STRAIN AND RELAXATION

As a rule, this condition is very amenable to conservative treatment. In cases of acutely painful relaxation the above-mentioned postoperative spica should be worn for 4 to 5 weeks, followed by a very long hip corset, made of heavy drilling, with steel stays incorporated into the sides and back. This should extend well up to the costal border, to prevent the corset from riding up on the pelvis, and should extend as low down as will permit the patient to sit. An inverted shield-shaped felt pad, 5 by 6 by ⅔ in., is fastened to the inside of the corset, so as to come over the sacrum. A 4-in. belt of webbing is adjusted to the lower end of the corset so as to grasp the pelvis just below the anterior-superior spines.

On account of the slowness of restoration of this joint, this belt should be worn for a year. In all subacute or chronic cases, the application of the above corset should be preceded by strapping the pelvis at intervals of 1 week with zinc oxid adhesive plaster, 2 in. wide, and a felt sacral pad, 5 by 6 by ⅔ in. (adult). In moderately severe cases, it has not been found necessary to fully encircle the pelvis in front, but the severe cases require a more rigid fixation, and the adhesive ends are brought together and lapped. This strapping should be applied very tightly, and continued at weekly intervals of change, until entire relief of pain is secured, at which time the patient is ready for the corset.

TUBERCULOUS OSTEITIS OF THE HIP

CONSERVATIVE TREATMENT

In the words of Tubby, "The ideal line of treatment of hip disease is early recognition, amply sufficient recumbency in the best hygienic surroundings, and when a suitable time has elapsed, carefully guarded ambulatory treatment; large amount of good food and good nursing; the whole routine to be conducted on the principle that if there is any error to be pardoned, it is rather in the direction of excess of care and time, than the reverse."

This excellently put statement, in my opinion, applies much more to tuberculous monarticular joint disease in children than in adults. In the adult, the treatment of all cases of any severity is essentially radical and operative for the purpose of obtaining early bony fixation.

It goes without saying that in this incidence, as in all other tuberculous joints, the best possible régime of life for tuberculous patients (viz. fresh air, sunlight, general rest, plenty of nourishing food) should be maintained at all times throughout the course of the disease.

Recumbent Treatment.—In all cases that are at all acute, the treatment should be begun by recumbency in bed with weight and pulley. The traction should always be applied in the line of deformity, if one exists, and should amount to about 1 pound more than the age of the child in cases over 2 years of age. This is a rough estimate, and the actual amount required should be determined in each individual case by close observation. The traction pulley should be adjustable (up and down) so that it can be lowered a little every few days until the deformity has been entirely overcome. The child should be prevented from sitting up in bed by fastening the shoulders to the mattress by straps, and from sliding down in bed by elevating the foot of the bed on blocks.

The traction in recumbency should be continued for weeks after all symptoms have subsided, when ambulatory treatment can be instituted in the form of a traction brace or a long plaster-of-Paris spica. The treatment should be ambulatory as early as expedient, because constant confinement to bed, unless absolutely necessary to control symptoms, injures the general health.

Ambulatory Treatment.—The Phelps hip brace (see Fig. 9) is the method of choice in all severe cases. This brace consists of a lateral upright extending from just above the thoracic border to below the shoe. To this is attached the foot-piece, with its weight-bearing surface covered with rubber, and to the upper surface of which traction-straps are attached; two trunk bands consisting of sheet steel and leather are also attached to the upright opposite the costal border and the anterior superior spines; just below the lower band an oblique ring (Thomas ring) is adjusted, to encircle the thigh at the groin, in which the body weight is suspended largely by its counter pressure in the region of the tuberosity of the ischium. Traction is maintained by moleskin stickers applied laterally to the limb from the groin to the ankle, which are attached by buckles to the foot-straps of the brace.

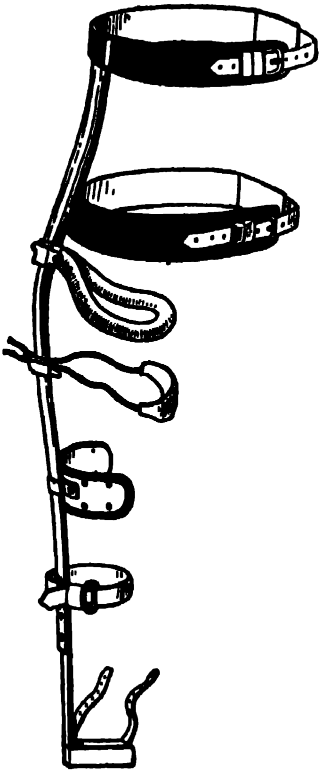

FIG. 9.—PHELPS HIP BRACE. This brace affords efficient fixation of the hip, as well as traction and prevention of weight-bearing.

The fitting of this brace is very important, and it should always be adjusted by the surgeon. A high cork shoe on the well foot and crutches should always be used with this brace except when it is transformed into a Plimpton convalescent hip splint by the adjustment of a light inner upright from the inner end of foot-piece to the inside of the ring and by the removal of the upper band.

In place of the convalescent brace the short plaster-of-Paris spica also furnishes a ready means of serviceable fixation of the hip until it is safe to leave off all support.

The greatest conservatism must be exercised in the final discarding of apparatus.

The long plaster-of-Paris spica, with a high shoe on the well foot, and crutches, may be the choice of treatment instead of braces.

The patient, anesthetized, if necessary, is placed upon a hip-rest, and the thigh abducted about 20°. The skin of the perineum and the bony prominences should be protected with cotton wadding, applied smoothly. If the case is a very acute one, the well thigh may also be included in the splint until evidences of marked sensitiveness have disappeared. The short spica should be used during the convalescence in precisely the same way as when the brace has been the initial treatment. A relapse should be managed by a return to recumbency with traction by weight and pulley.

Treatment of Cold Abscesses. A complicating cold abscess should be left alone unless distended, when aspiration or incision, under strict aseptic precautions, should be resorted to. Drainage should *never* be established except when necessitated by a secondary pyogenic infection. The contents of a cold abscess should be expressed with gentleness and without traumatization of the inside of the abscess wall by insertion of instruments, such as the curet, on account of consequent hemorrhage clot and infection. The incisions should be made through a thicker part of the abscess wall, at a distance from the apex, and should be closed in layers most carefully in order to insure primary union. The postoperative dressing is an important matter; it should consist of a large amount of fluffy gauze, with cotton externally, secured in place under even pressure, by a well-applied muslin spica bandage.

Correction of Deformity. Flexion, abduction or adduction, or any combination of these of slight degree, can be overcome by the traction and corrective influence of the Phelps brace. The severer cases, of not too long duration, can be corrected by recumbency on a bed frame and by traction in the line of deformity. As the deformity diminishes the traction pulley is gradually lowered so as to come nearer in line with the long axis of the body.

SURGICAL TREATMENT

Where the deformity due to tuberculous osteitis is resistant to traction, correction under an anesthetic may be necessary. Force should be used with great care, so as not to crush diseased bone or fracture the femur, already much weakened by disease or osteoporosis. Division by subcutaneous tenotomy of the contractured fascia lata or the adductor muscles may aid in certain cases in obtaining proper correction. The limb should be fixed in a plaster spica in the position of desired abduction.

When firm ankylosis is present, recourse to osteotomy is needed.

Technic of Osteotomy for Deformity of the Hip.—The curved Gant's osteotomy, as devised by Brackett, is by far the preferable procedure. Incision from just below the anterior superior spine, directly downward 5 or 6 in. exposes the line of division between the sartorius and tensor fascia femoris. These muscles must be separated nearly to their point of origin.

The retraction of the sartorius and rectus to the inside, and the tensor fascia femoris to the outside, exposes the anterior surface of the great trochanter and the upper end of the shaft. A blunt dissector is inserted vertically on the inner side of the bone at the point of junction of the lesser trochanter with the neck. With a very narrow, thin, and sharp osteotome, a curved incision is made with its convexity upward and inward, opposite the blunt dissector. A complete section is made vertically downward through the anterior and posterior cortex. (See Fig. 10.) When the leg is abducted in correcting the deformity, the convex end of the lower fragment turns in the concave surface of the upper fragment, with no possible chance of immediate or subsequent slipping or overriding. The limb is then included in a plaster-of-Paris spica from toes to axilla, in the desired abducted position.

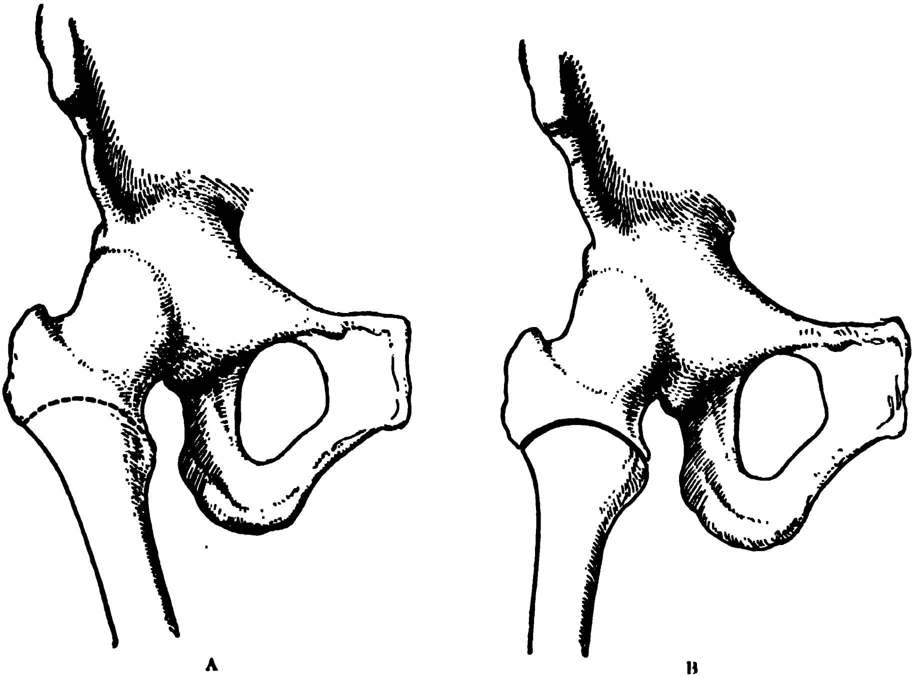

FIG. 10.—A—BONY ANKYLOSED HIP IN FLEXION-ADDUCTION DEFORMITY. B—CORRECTION OF ADDUCTION DEFORMITY BY CONVEX UPPER END OF FEMORAL FRAGMENT MOVING IN CONCAVE LOWER END OF UPPER FRAGMENT. Dotted line in A indicates bone incision of the circular Gant's osteotomy of Brackett. Note change in alignment of femoral shaft with pelvis. This procedure is used by the author for coxa vara. (Drawing from X-rays.)

HYPERTROPHIC ARTHRITIS DEFORMANS OF HIP

(*Osteo-arthritis, Senile Coxitis, etc.*)

On account of the anatomy and function of this joint, arthritis deformans in its advanced stage presents marked destructive changes, such as wearing away of the femoral head and acetabulum, eburnation, osteophytes, and deformity with accompanying pain. It is impossible by medicinal or conservative orthopedic treatment to overcome these marked pathological changes. Therefore, the author was induced (1907) to devise an operation to produce ankylosis which would relieve pain, overcome deformity, practical shortening and disability, and furnish a stable, weight bearing limb.

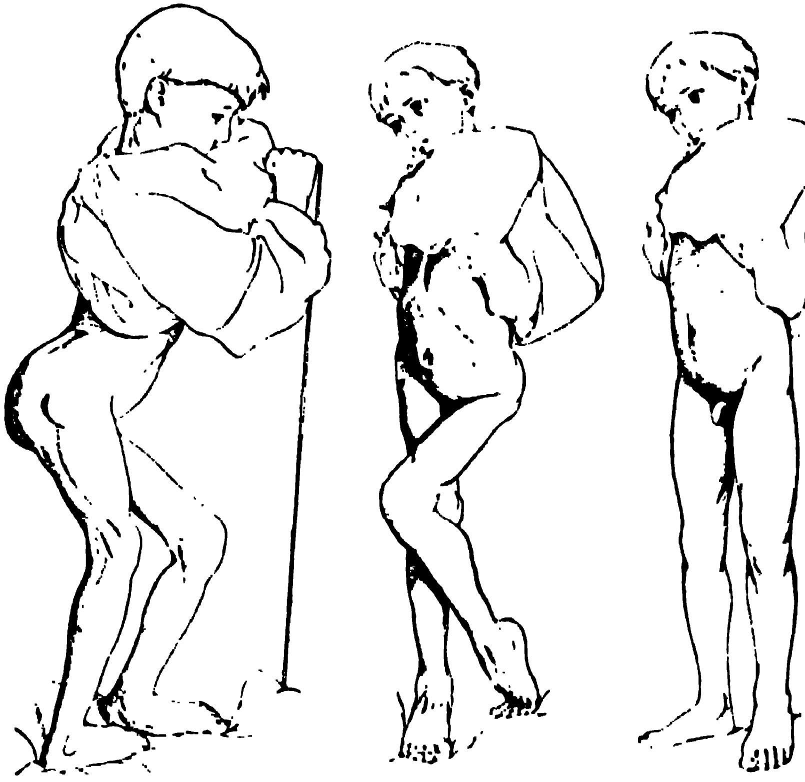

FIG. 11.—BEFORE AND AFTER CORRECTION OF FLEXION-ADDUCTION AT BOTH HIPS. The thighs were crossed and both hips ankylosed. If the ankylosis is bony a circular Gant's osteotomy (Brackett) is done; if it is fibrous a partial hip-joint resection (Albee's arthrodesis) or arthroplasty for mobility is done and deformity corrected. See description of operation for osteo-arthritis of hip. (Drawings from photographs.)

Albee's Operation.—TECHNIC. The hip-joint is reached by an incision from the anterior superior spine, obliquely downward and outward to the middle of the outer side of the trochanter, and is then turned downward 2 in. in the line of the femur. At the point where the oblique portion joins the vertical, just over the trochanter, an incision is made directly backward, 2 to 3 in., down to the fascial portion of the gluteus maximus. After separating the tensor fascia femoris and the gluteus medius, the line of separation is extended downward along the line of the original incision, through the fascia lata to the femur, freeing the attachment of the muscles (vastus externus) from the outer and upper surfaces of the femur. The fascial expansion of the gluteus maximus is then cut through along the line of the posterior part of the original incision, and the outer part of the trochanter exposed.

"This gluteal flap is turned backward, and the outer and upper surfaces of the trochanter fully exposed. The upper portion of the trochanter is then chiseled off by cutting directly backward with a narrow osteotome, on a curved line beginning on the outer surface of the trochanter, 1½ in. below the tip, and cutting inward for ¼ in., then curving upward to the fossa at the junction of the upper part of the neck and the trochanter. This removes the outer portion and tip of the trochanter, and with it the attachments of the gluteus medius, gluteus minimus, and pyriformis. Care should be taken in the removal of this piece not to encroach on the neck, or the bone will be weakened at this angle. The portion of bone removed, with the muscles attached, is deflected backward and upward enough to uncover the upper part of the femoral neck, and the muscular covering of the anterior fibers of the gluteus medius and minimus is easily separated from the region above the acetabular rim. The incision through the trochanter just borders on or opens the outer edge of the capsule on the upper surface of the neck, and the incision of the capsule opens directly into the cavity of the joint.

"The capsule may be split along its upper surface, parallel to the neck, and near to its acetabular insertion cut transversely on each side, which opens the view of the edge of the head and the rim of the upper half of the acetabulum" (Brackett).

The osteophytes about the rim of the acetabulum are dislodged by means of a chisel and turned upward with the adherent soft tissues, to be turned back and used later on account of their bone-producing ability. The rest of the overhanging acetabulum is removed, exposing the anterior lateral portion of the head. With a thin chisel, 5/8 in. wide, approximately one-quarter of the upper part of the head of the femur is removed in a plane with the neck. The detached portion of the head is then broken up with a narrow osteotome, and the fragments extracted with a strong forceps. The acetabulum is then transformed to a flat roof by means of the chisel and strong curet, sloping upward internally to prevent the head from dislocating. Rotating the thigh inward and outward, every accessible bit of cartilage is removed from the remaining portion of the head. The peri-articular structures are drawn together with a few stay sutures of kangaroo tendon. The gluteal flap, with the great trochanter, is turned down and likewise sutured in place. The detached portion of the trochanter is secured in position by two sutures of kangaroo tendon placed through drill holes. The skin is approximated by continuous catgut sutures.

POSTOPERATIVE TREATMENT.—The limb is placed in 10° flexion, and sufficient abduction to overcome the practical shortening from the deformity and the actual shortening from the destructive disease and the removal of bone at operation. If sufficient abduction is not allowed on account of the contracted adductors, they should be divided near their origin through an open incision.

The fixation dressing should consist of a double plaster-of-Paris spica extending from well above the costal margin to the toes on the operated side and to the knee on the well side. The well leg should be placed in strong abduction, as in this position the femur acts as an efficient lever to prevent the riding up of the pelvis on the diseased side.

The plaster may be removed from the unoperated leg in 2 weeks. The patient should remain in bed 5 weeks. The long plaster spica can be changed to a short one at the end of 7 weeks, after which weight-bearing is permitted.

In muscular individuals, a U-shaped piece of strong brace-steel is incorporated under the last few plaster bandages, to prevent the strong pull of the adductor muscles bending the unset plaster, and thus allowing a relapse of the deformity. The steel is easily removed when the plaster is taken from the well thigh.

SCOPE OF ALBEE'S OPERATION.—The above procedure is equally applicable in adult tuberculous osteitis; deformity following old tuberculous osteitis or infectious arthritis (in place of Gant's osteotomy); traumatic conditions and old fractures of neck of femur near the head which are painful and need an open operation; cases of dangle hips where there is paralysis of both hips and the lumbar spine with contractures of the fascia lata. The ankylosis of one hip in good position holds the pelvis upright, corrects lordosis and facilitates bracing.

CERVICAL COXA VARA

As this condition is almost invariably due to rickets, it is necessary to wait for the subsidence of incident bone softening, which may be hastened by proper rachitic treatment.

The operative technic of choice is that of Gant's circular osteotomy (Brackett), which has been fully described as the means for correcting ankylosed deformities following tuberculous osteitis of the hip-joint (see Fig. 10).

The leg is inclosed in a long plaster-of-Paris spica from the axilla to the toes, at a degree of abduction determined previously by the study of the amount of depression of the head and neck, as shown by X-ray and by the amount of shortening of the leg.

On account of faulty bone metabolism and the lateral stress to which the new union is subjected, it is imperative that the leg be supported in abduction for at least 4 months after operation. This can best be accomplished by the plaster-of-Paris spica.

EPIPHYSEAL COXA VARA

This type of coxa vara, in contradistinction to the cervical, is found at the adolescent period of life (10 to 20 years). It is not due to bone softening, but to a weakening of the epiphyseal cartilage, and is the only epiphyseal cartilage known to give way spontaneously. It may give way from severe trauma, and is then considered an epiphyseal fracture. The treatment in either instance is precisely the same and is as follows:

Manipulative Treatment.—If the separation is a fresh one, then manipulation should be tried, consisting of strong traction, both longitudinally and laterally, on the upper end of the femur, abduction and marked internal rotation, in which position the limb should be fixed in a long plaster-of-Paris spica and the part radiographed to see if a good reposition has been secured. However, on account of the upper fragment being difficult to control, the possibility of securing a good reposition is uncertain and an open operation is usually necessary. In either event, if it is possible to replace the fragments, they can be held perfectly without metal spike or suture, by the above-mentioned position of abduction and internal rotation, as pointed out by Whitman. By this position, the fractured end of the neck, which is always displaced forward in front of and above the head, is forced backward in apposition to the fractured surface of the head and the unruptured posterior portion of the capsule is put on tension and serves as a splint. The element of abduction carries the upper end of the lower fragment under the rim of the acetabulum, and prevents danger of displacement upward of the lower fragment. The inward rotation is the difficult part of this position to hold, and I therefore flex the knee to a right angle and make use of the leg as a lever, thus holding the replaced fragments securely. A plaster-of-Paris spica from the toes to just above the costal margin is applied with the leg in the above position.

The patient is placed obliquely in bed, with the flexed leg hanging over the side of the mattress. At the end of 10 days that portion of the spica below the knee is removed, the leg straightened and inclosed in a cast, in this position, to the toes. The long spica should be continued for 10 weeks, and then should be followed by a short one, with weight-bearing, for 4 weeks.

Operative Treatment.—If it is impossible to reduce the fragments by the bloodless method, the hip-joint is reached by an anterior incision, starting from just inside the anterior superior spine of the ilium, and carried directly downward for 5 in. The point of fracture is then exposed by blunt dissection through the muscle planes.

The fractured end of the femoral neck (lower fragment) presents in the wound. The location of this head to the uninitiated may be puzzling on account of its lying behind and being obscured by the neck. The neck is separated from the head by a blunt dissector or chisel, which is then used to pry the fragments into position, at the same time that strong traction (both lateral and longitudinal to the femur), abduction and inward rotation are applied to the limb. The wound is closed by continuous catgut suture. With the leg flexed to a right angle on the thigh, a plaster-of-Paris spica is applied in the same manner as in the closed method, above described, and the post-operative treatment is also the same as in the bloodless method.

FLEXION-ABDUCTION DEFORMITY OF THE THIGH IN ANTERIOR POLIOMYELITIS

This deformity is due to the contracture of fascia lata and the tensor fascia femoris muscle, due to their relaxed state, from the leg's remaining in the frog position for a long period of time during the early stage of the disease.

These deformities are corrected by open tenotomies of the contracted structures at a point just below the anterior superior spine. The tissues are picked up on a curved grooved director and inspected before being divided. The limbs are stretched in hyperadduction and extension. If it is found unnecessary to tenotomize further, the wound is closed by continuous catgut suture, and the limbs placed in adduction and extension in a long plaster-of-Paris spica for 6 weeks.

Massage and stretchings should be carried out periodically. Relapses are frequent, and, therefore, braces to prevent flexion are indicated in the severe cases.

TUBERCULOUS OSTEITIS OF THE KNEE-JOINT

This is next in frequency and importance to tuberculous osteitis of the hip-joint. Here, as in tuberculosis elsewhere, a strict hygienic régime should be enforced.

This joint responds favorably to treatment on account of its character, size, and strength. It is at a distance from the trunk, and being the articulation between the two longest bones of the body, allows long leverage action in securing fixation by conservative means.

The Thomas knee brace (see Fig. 12) provides the most efficient means of conservative treatment as it not only furnishes traction — an important essential of fixation — but fixation direct.

It consists of 2 iron wire uprights, about 3/8 in. in diameter, connected above with an ovoid leather-padded iron wire ring, 1/4 to 1/2 in. in diameter, welded to the uprights with a lateral (135°) and anterior-posterior inclination. At the lower ends a foot-piece shod with rubber is welded. Spanning the uprights at the calf, and just below the middle of the thigh, are two broad bands of leather arranged to half encircle the leg posteriorly when the brace is in place. To the foot-piece, which should be 2 or 3 in. below the sole of the shoe, are fastened at either side 2 leather straps, which are to fasten into the buckles at the lower ends of the adhesive traction straps applied to the leg from the knee to the ankle. These straps not only produce the desired traction, but hold the brace firmly in place. A bandage is carried to and fro around the uprights and fastened in front of the leg, just above the knee, where it passes over a thick pad of felt placed over the lower end of the thigh. In a similar way, a bandage and pad are placed just below the knee-joint.

By the pressure of the pads and the traction a small amount of deformity can be corrected.

In very sensitive cases, tending toward deformity, a snug fitting plaster-of-Paris splint is applied to the leg and the brace placed over it.

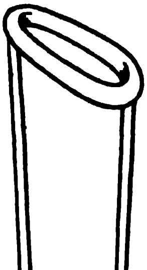

FIG. 12. — THOMAS KNEE BRACE. It is used to immobilise and relieve weight-bearing of knee or ankle.

This brace is used to advantage at all stages of the disease. It provides fixation support, shields the joint from weight-bearing by transmitting the body weight to tuberosity of ischium. It produces traction and a strong corrective force in deformity. It relieves intra-articular pressure, and is used in bed as well as in ambulatory cases. In the latter usage, a cork extension sole, from 2 to 2½ in., is applied to the shoe of the well side and crutches aid in locomotion.

In very severe cases recumbency, with weight and pulley traction, is carried out to control symptoms in the manner described for hip disease. Cases which are markedly flexed and resist correction by traction in bed can be overcome by forcible stretching under anesthesia.

The following technic, suggested by Whitman, is both efficient and safe. The patient is placed in the prone position, with the feet projecting over the end of the table. "The body of the patient is then elevated by means of pillows to conform to the deformity, that is, the thigh of the affected limb is raised sufficiently to allow the tibia to lie evenly upon its anterior border on the table. The operator with one hand holds the head of the tibia against the table, and with the other massages the contracted tissues of the popliteal region, gradually exerting more downward pressure on the thigh, but never to the extent to lift the tibia from the table; thus, further luxation is impossible. As the contraction gives way, the pillows are removed." The limb is placed in a retaining plaster-of-Paris splint for from 3 to 4 weeks.

If correction is not possible by this method, open tenotomies are made of the contractured hamstring tendons. Care should always be observed to avoid dividing the external popliteal nerve. In the extreme cases of contracture a supracondylar osteotomy is necessary for complete correction of the flexion.

Cold abscess of the knee is treated precisely the same as in other joints.

During the active stage of the disease the brace must be worn night and day. As the disease recedes, there comes a time when the brace may be left off at night. This step should be taken with the greatest caution. Somewhat greater freedom can be exercised than in the case of hip disease.

Plaster-of-Paris casts can be used to advantage in emergency and for complete treatment in milder cases.

SYNOVIAL TUBERCULOSIS OF THE KNEE

This type of the disease is very difficult to differentiate from the osseous type in the child, but the treatment, fortunately, is the same.

Tuberculosis of the adult knee, both of the synovial and osseous type, is operative, except in very mild cases, or when the patient elects to devote years of his life entirely to convalescence. This applies also to the adolescent who has nearly reached his growth. Excision of the knee in children is abandoned on account of the shortening resultant from the damage to the epiphyseal cartilages in the region of this joint, and is practiced only as a life-saving measure.

The object of excision is not necessarily the eradication of all the disease by the removal of a large amount of bone, but it is for the purpose of securing bony fixation by the removal of its barriers, namely, synovial membrane, cartilage and superficial joint foci, and the approximation of the largest bone surfaces for early and strong union.

On account of the danger of long delayed union or its entire absence, as an adjunct to erasion or excision, Albee's inlay bone graft offers trustworthy means of securing early and certain results without distortion.

Erasion of the Knee-joint, with Bone Transplantation: Albee's Technic. --This procedure is for the treatment of acute adult tuberculosis and the correction of complicating deformities, such as fibrous or incomplete bony union.

Before entering the tuberculous joint a graft, 6 in. long, is removed from the anterior internal surface of the tibia by the twin saws (adjusted 7/16 in. apart) and placed in saline solution until wanted. In cases where the patella has not been too much involved, I have used the patellar instead of a tibial graft. By sawing it into inlay grafts, it serves the purpose very well.

With an Esmarch bandage about the upper thigh, the knee-joint is reached by a large U-shaped incision, with the lowest point of its curvature over the tubercle of the tibia. The ligamentum patellæ is divided at its insertion, and the patella is turned upward and removed. The lateral ligaments are cut and the leg flexed on the thigh to the extreme.

The tuberculous soft tissue is trimmed away with scissors. With a narrow bow saw a thin section, consisting of the cartilage, with the underlying bone $1/4$ to $1/3$ in. in thickness, is removed by a saw cut approximately parallel to the convexity of the condyles of the femur. With the same instrument, a section about the same thickness is removed from the head of the tibia by a concave cut, producing a surface which will fit over the convex surface already prepared on the condyles of the femur. The bone should be so removed that when the cut surfaces are approximated the leg is straight.

The anterolateral surfaces of the upper end of the tibia and the lower end of the femur are each exposed for about 3 in. The periosteal structures are incised down to the bone on each side of the patella on both tibia and femur, parallel with their long axes, and turned sideways with the periosteum elevator.

With the circular motor twin saws adjusted the same as when removing the graft, and the tibia and femur held in good apposition, 2 parallel cuts are made 3 in. into each bone, at their anterolateral corners on either side of the patella. The strips of bone between the saw cuts are removed with a small motor burr and narrow chisel.

Holes to receive graft-retaining kangaroo sutures are made in the cortex laterally to the gutter in each bone, or the grafts may be held by autogenous dowel grafts, as described elsewhere. The sutures are inserted by large curved needles or flexible probe, and pulled up from the bottom of the gutter in the form of large loops, under which the graft is placed and pressed into its bed. The sutures are then drawn tightly in place over it and tied. The graft, thus applied, assumes efficient fixation and supplies an active osteogenetic factor and stimulus to the bones into which it is inserted without the use of foreign material, such as metal plates, screws or wire.

The necessity in these cases for some internal fixation has been appreciated in the orthopedic service of the Massachusetts General Hospital, according to Dr. Goddu, since December, 1909, and internal metal plates and clamps have been used in all excisions of knees, and, even under these conditions, 2 out of 8 cases required reëxcisions on account of inability to form sufficient callus. Goddu mentions 27 cases done without Lane's plates in 3 years, of which only 4 showed union within 6 to 12 weeks, 4 required reëxcision, and in 1 silver wire had to be removed on account of a discharging sinus.

"In three cases where the bones were drilled and held by suture material, in one the suture broke, allowing displacement of ends of femur and tibia, and a reposition under ether was necessary,—in one other there was considerable motion at the end of eight weeks."

On account of similar experience I have used, instead of a metal plate, the inlay bone graft, which I believe to be far superior.

BONY ANKYLOSIS OF KNEE WITH DEFORMITY

Bony ankylosis with deformity can be overcome in one of two ways: by removing a bone wedge from the maximum of the convexity or by a linear osteotomy, just above the knee-joint. The latter procedure is preferred in young subjects, on account of less danger of epiphyseal damage, and in cases where there are marked cicatrices about the joint on account of less danger of interference with the compensatory return venous circulation.

FLEXION DEFORMITY OF KNEE WITH MOTION

Osgood has offered a very satisfactory operative method for correcting long-standing flexion deformities of the knee where the contour of the joint has so changed that there is little likelihood of regaining full extension without an osteotomy of the lower end of the femur.

Such cases may be the result of tuberculosis, various infections, or joint fractures.

Osgood's Operative Technic (see Fig. 13).—"A two-inch linear incision is made on the outer side of the leg, posterior to the edge of the upper cul-de-sac of the knee-joint, and extending upward from about the level of the upper border of the patella. This incision is carried down to the bone, and with a blunt dissector a space is cleared over its upper surface. A second incision is then made at the same level on the inner side of the femur, and a similar space cleared beneath the cul-de-sac over the upper surface of the femur joining the space made through the outer incision.

"The flexible blade of an ordinary coping or jig saw (Fig. 13) is now pushed through, teeth down, in the path made by the blunt dissector and inserted in the arms of the bow; the blade passes over the top of the bone beneath the upper cul-de-sac.

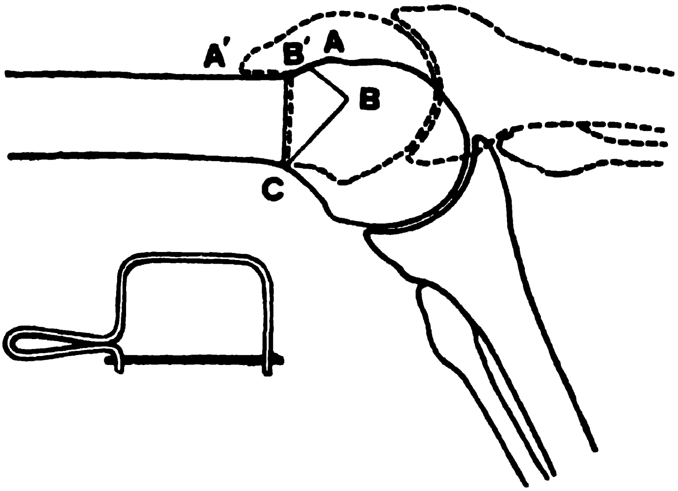

FIG. 13.—DRAWING OF MECHANIC'S COPING SAW AND DIAGRAM OF OSTEOTOMY FOR STRAIGHTENING KNEE, SO AS TO PRESERVE FREE MOTION WHEN IT EXISTS. Saw is entered at A, by freeing its end temporarily from bow. Saw incision to B and thence to C. At C saw is removed from bow and left for orientation. Another saw is entered at B' and bone incision to C is made. Quadrilateral piece A, B, C, B' is pushed out laterally. Leg straightened bringing A' to A and B to B'. (After Osgood.)

The first cut is made forward and slightly toward the posterior surface of the bone, toward the lower end of the femur for about ¾ to an inch, and then inclined sharply downward, i. e., toward the posterior surface of the femur backward, that is, toward the upper end of the table.

"When the posterior cortex has been partially sawed through, the arms of the bow are removed and the detached saw, left in as a marker for orientation. A second saw blade, teeth downward, is now passed through the path above the bone, and made to engage it above the entrance of the first saw depending upon the size of the wedge required.

"A cut is now made in a straight line down to the position of the first saw and both saws removed. Thus a quadrilateral portion of bone is freed which is pushed out through one of the incisions.

"Extension is then made and either a green-stick or a complete fracture of the posterior cortical shell is made, while the lower end of the upper fragment is forced against the upper end of the lower fragment, which projecting upper lip made by the first saw cut keeps it from displacing backward and apparently quite firmly anchors it.

"After closure of the wounds a plaster-of-Paris dressing is applied and in our cases union has apparently been firm in from four to six weeks."

GENU VALGUM

(*Knock-knee*)

Genu valgum or knock-knee (see Fig. 14) occurs almost wholly in early childhood and is usually due to rickets, occasionally to infantile paralysis.

During the acute stage of rickets it should be unnecessary to emphasize the importance of establishing a proper constitutional treatment. This should be supplemented by local massage, corrective manipulations and exercises. Accurate tracings should be kept during this period as a record for determining progress. If distinct improvement is not manifest or the age of two years has been reached with considerable deformity, more radical measures are indicated.

Treatment by Braces.—Corrective braces should be applied to all cases of knock-knee of any severity up to the age of 2½ years. One of the simplest and most efficient braces is that devised by Thomas, which consists of a light steel upright with a trochanter pad at its upper end, with free motion in a joint opposite the hip articulation and a padded band to encircle the pelvis at the level of the anterior-superior spines. The lower end of the upright is rounded and bent at right angles, and inserted into the anterior portion of the heel of the shoe. The knee is fixed by a posterior bar attached to a thigh and calf band, as shown in Figure 12.

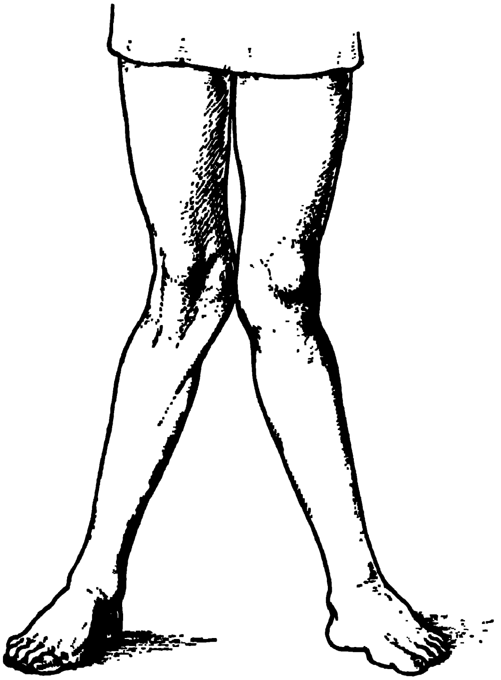

FIG. 14.—GENU VALGUM. Knock-knee, corrected by supracondylar osteotomy.

When the brace is applied, the knee is held backward and outward under tension by an internal lateral pad fastened to the posterior band upright by straps and buckles or by roller bandage. In severe cases the uprights are bent to conform somewhat to the limb, and as the deformity recedes they are gradually straightened until slight overcorrection of the deformity is secured.

The braces are removed daily for massage and manipulations. In children of 2 years or over, of large size and severe deformities, braces should be worn at night as well as through the day. The duration of brace treatment varies from 6 months to a year, and depends upon the degree of deformity, the efficiency of the apparatus, and the age of the child.

Operative Treatment.—Operative treatment is indicated in all cases where the deformity is at all marked in children over 3 years of age. It is most satisfactory at all ages, excepting during the acute stage of rickets.

The operation of choice is, by all means, osteotomy, although Blanchard obtains excellent results by osteoclasis. Personally, the supracondylar osteotomy from the outer side, as advocated by MacCormac, is preferred. This may be accomplished by a narrow osteotome or saw. A sharp osteotome, ½ in. wide, is the preferred instrument. The field of operation is prepared in the usual way, the limb is rotated inward and placed upon a sandbag opposite the point of bone section. With the cutting edge of the osteotome parallel with the long axis of the femur, it is pushed cornerwise through skin and underlying structures to a point on the external surface of the shaft of the femur, about a finger's breadth above the upper border of the external condyle. A few taps of the mallet incise the periosteum. The osteotome is then turned at a right angle to the femur, and a gauze sponge is placed around the osteotome and in contact with the skin. By repeated blows of the mallet 2/3 of the outer femur shaft is cut transversely, with the chisel held as in Figure 15, as in this way the possibility of driving the chisel too far through and entering the popliteal space is lessened. A green-stick fracture is then made of the remaining portion of the shaft. There may be some bleeding from the osteotome wound. It is, however, far preferable to leave it unsutured and allow the excess blood to escape, rather than to contribute to a hematoma in the soft parts by suturing the wound.

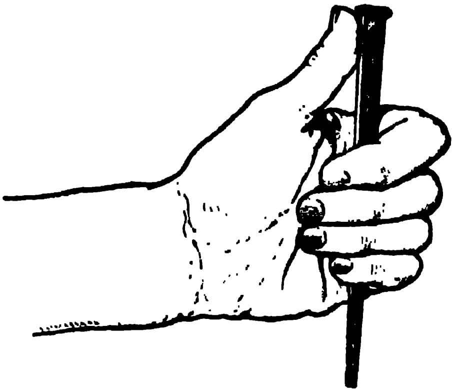

FIG. 15.—THE OSTEOTOME AND THE PROPER WAY TO HOLD IT. It is a firm way to hold the osteotome and lessens the danger of its being driven into soft tissues beyond bone being osteotomized.

The deformity is then well overcorrected and placed in a plaster-of-Paris spica from the toes to include the pelvis.

If the deformity is bilateral, both legs are operated, and a double spica is applied as the dressing. In this case, it is applied with the limbs widely abducted, and to strengthen the plaster a piece of splint board, long enough to span the distance between the limbs just below the knees, is incorporated in the last layers of the plaster bandage. This position of the limbs favors the use of the bed-pan, and prevents soiling of the dressings.

The dressing should remain on for eight weeks, and it should be determined in each case whether the plaster dressing should be followed by knock-knee braces for a longer period. In some cases of marked rachitic involvement supports should be worn for several months.

In certain cases, where in addition to the femoral deformity there is a severe deformity at the upper end of the tibia, this may be rectified at a second operation by an osteotomy at the tubercle of the tibia. In exceptional cases, where the deformity is wholly in the tibia, an osteotomy of that bone may be all-sufficient.

GENU VARUM

(*Bow-legs*)

As this deformity (see Fig. 16) is usually due to rickets, the outline of the general treatment is precisely the same as for knock-knee, and the milder cases are treated by expectancy, massage, and braces. The application of braces here has a broader field of usefulness, and the prognosis is more favorable than in knock-knee.

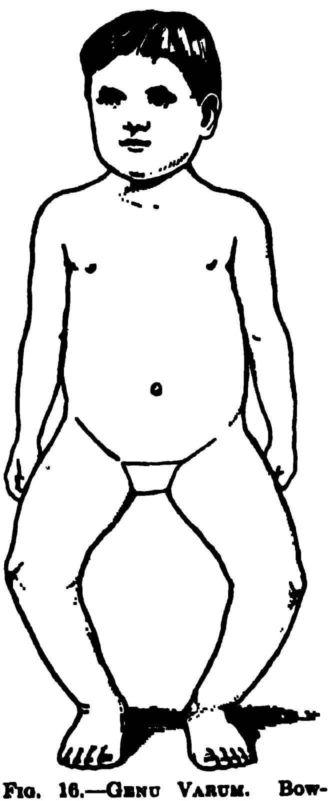

FIG. 16.—GENU VARUM. Bow-legs corrected by osteoclasis or osteotomy at point of greatest curvature.

The deformity of bow-legs is usually wholly confined to the tibia, and is most commonly found in the lower 2/3 of this bone. When the deformity is that of a general bowing of the tibia, brace treatment may be sufficient up to 2½ years of age; beyond that time the treatment should always be operative.

Treatment by Braces.—Where the deformity is in the lower 2/3 of the tibia, the Knight brace is the one of choice. This consists of 2 steel uprights attached to the shoe below; a soft leather pad for pressure over the inner condyle of the femur is attached to the upper end of the inner upright. The outer upright extends to the head of the fibula, and the 2 uprights are joined by a calf band. The bowed leg is drawn toward the inner bar by a broad leather cuff, laced about the leg inside of the outer bar.

As the deformity recedes, the inner bar is bent until overcorrection is secured, as in the case of knock-knee treated by the brace method. This is usually accomplished in young children in from 6 to 12 months.

If the deformity is higher up and associated with outward bowing of the knee, a longer apparatus is necessary, with no joint at the knee. Such a brace is very similar to the short brace just described, except that the inner upright extends to the upper third of the femur and the outer upright to the pelvis, where it is attached to a pelvic band. A joint is placed in the outer upright opposite the hip articulation. The leather lacing encircles the knee and upper part of the leg, and serves to improve the contour of the leg by drawing it to the inner upright.

The corrective action of the brace progresses by bending the uprights to a better position from time to time.

Operative Treatment.—The operation of choice is that of osteoclasis by the Grattan osteoclast (see Fig. 17), except when the curve is sharp and is situated near the knee- or ankle-joint, such as the anteroposterior curve in the tibia near the ankle-joint (the chair-deformity). Here the osteoclast has the same disadvantage as in knock-knee. On account of the nearness to a joint, and the increased density of the bone cortex at that point, it is difficult to direct the force so as to produce a fracture at the maximum of the curve. Under these conditions, linear osteotomy is preferred.

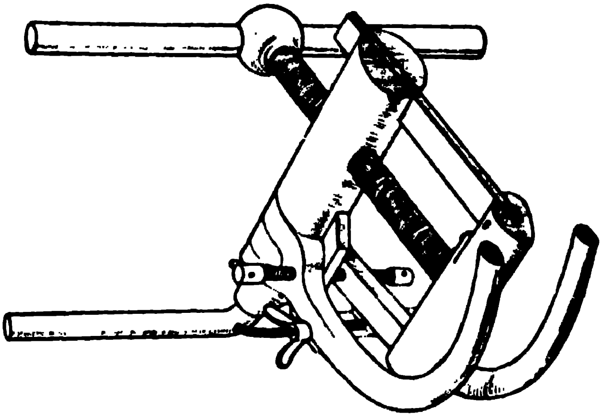

FIG. 17.—THE GRATTAN OSTEOCLAST USED PRINCIPALLY FOR THE CORRECTION OF BOW-LEGS. It has also been used for correction of knock-knee and malunited fractures. Mr. Grattan, of Cork, whose name it bears, used it to crush and overcorrect club feet.

OSTEOCLASIS.—In osteoclasis the point of greatest deformity should always be selected for fracture. With the arms of the osteoclast from 3½ to 5 in. apart, the concave side of the limb is placed against them, and the maximum of the convexity is opposite the plunger. The limb is then firmly held on either side of the arms by an assistant, while the plunger or breaking bar is rapidly screwed down until fracture occurs, and then quickly reversed. The immediate release of the pressure of the plunger is imperative in order to prevent sloughing of the skin and underlying tissues. The limb is overcorrected and fixed by plaster-of-Paris dressing.

Manual force over a Lorenz wedge or the edge of the operating table padded with a folded sheet is sufficient to produce the fracture in many cases of young children.

OSTEOTOMY.—An osteotome ½ in. wide, with the cutting edge parallel with the long axis of the leg, is pushed cornerwise through skin and subcutaneous tissue to the internal aspect of the tibia. It is then turned to a right angle to the limb and the tibia weakened on the inner side sufficiently to allow fracture by manual force. The limb is overcorrected until the fibula is also broken. A plaster-of-Paris splint is applied, reaching from the toes to the

groin, with the leg in the overcorrected position. This is to remain on from 6 to 8 weeks.

ANTERIOR BOW-LEGS

A linear osteotomy is done by the technic already described. The fracture of the tibia and fibula is completed by manual force. Tenotomy of the tendo Achillis is necessary if correction of the deformity is prevented while the foot is in a position of a right angle to the leg.

FLEXION CONTRACTION AT THE KNEE FROM ANTERIOR POLIOMYELITIS

This contracture many times will give way by manual stretchings under anesthesia. An efficient and safe method is that suggested by Whitman, previously referred to under the technic for correcting contracture following tuberculous osteitis of the knee (see page 191).

TUBERCULOUS OSTEITIS OF THE ANKLE AND TARSUS

Conservative Treatment.—In this as in other tuberculous joints both local and general rest should be carried out. Local fixation is best accomplished by a plaster-of-Paris cast from the toes to the calf, with the foot at a right angle and slight varus position. Over this should be placed a Thomas brace, as described in the treatment of tuberculous osteitis of the knee (see page 191).

It is evident that traction cannot be applied here as used in the case of the knee or hip, and to hold the brace in position and prevent its dropping a webbing strap is adjusted over the opposite shoulder.

Operative Treatment.—As a rule, operative interference is unsatisfactory, especially early operations of a gouging nature. However, if by the X-ray a well-focalized condition can be demonstrated, as, for example, in the astragalus, the removal of that whole bone is the operation of choice.

TECHNIC.—Under an Esmarch bandage a curved incision is made from a point one inch above and posterior to the external malleolus, and carried under the malleolus and forward to the outer aspect of the astragaloscaphoid joint. The external lateral and capsular ligaments are severed and the foot turned inward. The astragalus is exposed and removed by dividing the capsular ligaments joining it to the os calcis and scaphoid. Infected soft tissues are carefully removed. If there is no evidence of secondary infection, the wound is closed without drainage; otherwise it is packed for a while with gauze.

The after-treatment should be carried on precisely as if no operation had been done.

CONGENITAL TALIPES EQUINOVARUS

(*Club-foot*)

The treatment of congenital club-foot should be begun at the earliest age possible and should be persisted in until all tendency to recurrence of deformity and restricted function is overcome. In infancy, manual stretching and fixation in plaster-of-Paris, without tenotomies or an anesthetic, suffice, as a rule. After the walking age, more radical measures are usually necessary, such as subcutaneous tenotomies of the tendo Achillis and plantar fascia under anesthesia, followed by stretching and fixation in plaster-of-Paris—later, in a brace.

At a still later period—in untreated or relapsed cases offering, besides the resistance of the soft parts, resistance of malformed tarsal bones—the foot must be remodeled by operative intervention and held in a corrected position. These cases usually include those over 3 years of age, and the implantation of the bone-graft wedge into the short side, as will be described later, is the method of choice.

TREATMENT IN INFANCY

The technic of treatment of club-foot in infancy, described by Soule in the *Journal of the American Orthopædic Association*, May, 1911, is the one of choice. By manual stretching at intervals of 1 to 2 weeks, the foot is overcorrected to a degree in calcaneovalgus equal to, or even greater than, the original degree of equinovarus deformity. The correction of the varus of the foot should be first accomplished, followed by the correction of the equinus. This is usually accomplished in early cases without an anesthetic, in 4 to 6 stretchings, at weekly intervals. By his method of applying the plaster-of-Paris fixing dressing, the loosening or kicking off of the cast is prevented; and excoriations and macerations of the skin, and partial relapse of deformity while in the cast, are obviated.

The leg and foot are lightly bathed with alcohol and, after thorough stretching without tearing or lacerating the soft parts, zinc oxid adhesive plaster is applied to the skin of the instep and inner surface of the great toe joint, to prevent abrasions of the skin by the chafing of the plaster dressing. A strip of the same plaster 1 to 1½ in. wide by 8 in. long, folded upon itself at one end to form a non-adhesive lip about 2 in. long, is applied to the leg, partially about the calf in an oblique direction from above downward, so that when the free lip end of adhesive plaster is incorporated in the plaster dressing the pull of the adhesion strip prevents any relapse or rotation of the foot inward on the leg, and also prevents the child from kicking the cast off the limb, as sometimes happens in cases of fat chubby legs and short thick feet, particularly in the first few stretchings when the equinus is not corrected. Strips of absorbent cotton are placed between the toes to take up moisture. A

2-in. soft Shaker flannel bandage is then applied as a lining to the cast, extending from the toe to the knee, allowing the free lip of the traction adhesive strip to protrude between the overlapping layers of the flannel bandage.

The foot and leg are now ready for the application of the plaster-of-Paris bandage, which should be 2 in. wide and 3 yd. long. This is applied by the surgeon while holding the foot in its overcorrected position, beginning at the toe, in a smooth simple spiral up the leg and under the free lip of the traction adhesive to the knee, then returned down the leg over the adhesive lip, drawn tight, and so on to the toes. The flannel edge at the top is turned down over the edge of plaster, and the same is done at the toes, to form soft borders to the finished cast. During the application of the plaster bandage, the limb is held slightly flexed at the knee by an assistant. The holding of the foot and the application of the bandage are done by the surgeon alone, as the parts are too small to allow of other assistance in the application of the cast.

After the cast has sufficiently hardened to permit the surgeon to release his grasp, the toes are inspected to see that the circulation has not been interrupted. The plaster bandage should not be drawn so tight in making the turns, or be allowed to wrinkle, so as to interfere with circulation. The appearance of the toes—and each toe should be inspected—should be a normal pink, neither blanched nor cyanosed. Slight pressure on each will denote that the circulation is not interrupted.

The first 2 or 3 stretchings are the most painful to the child and give discomfort for the first 48 hours thereafter; from then on the baby suffers little discomfort from the changes in the plaster. The child can walk freely in the plaster cast, as applied, since it is light and not carried above the knee joint.

When overcorrection is easily and well maintained, and it is desirable to allow more freedom of movement, adhesive plaster strapping is substituted for the plaster cast and is applied to hold the foot in marked abduction, pronation, and dorsiflexion. A strip 1½ in. wide, and sufficiently long to encircle the fore-foot and pass obliquely up and about the outer surface of the calf, with the foot well overcorrected, is required. The 2 ends are secured in place by additional adhesive strips—one to encircle the calf, to hold the upper end; and a second, applied across the dorsum of the fore-foot and around the outer ankle, to secure the lower end. A flannel bandage is applied over all.

Soule has devised a sling brace to accomplish the same result in holding the foot in abduction and dorsiflexion. It is composed of a canton flannel loop to encircle the foot and ankle, and is continued up the outer side of the leg by a webbing strap, to be fastened to the upper end of a steel upright, which is secured to the calf by a band about the leg, and to the shoe below. A joint with a catch to prevent toe drop is made in the upright at the ankle joint. With this sling brace adjusted, the child's foot, when walking, is pulled outward and upward with each step, which is in the direction toward correction of the varus and equinus. It is simple and easily adjusted and worn, and is the most efficient form of brace to maintain overcorrection of the foot. It is also well to thicken the sole of the shoe on the outer side.

OPERATIVE TREATMENT IN CASES OVER TWO AND A HALF YEARS OF AGE

Mild Cases

Mild cases of club-foot and cases that have partially relapsed from previous treatment in the long type of foot are amenable to subcutaneous tenotomies and forcible stretchings, either manual or instrumental, under anesthesia. In these cases, the tendo Achillis and plantar fascia are the usual tissues needing tenotomy. (See Fig. 18.) The foot is overcorrected and placed in a plaster-of-Paris cast from the toes to above the knee, with the foot abducted and the knee flexed to near a right angle, to prevent rotation inward of the foot in the plaster.

Severe Cases

The severer types of club-foot may be considered under two groups, in order to simplify the description and choice of method of treatment. The salient characteristics of the first group are: a foot not markedly shortened; marked adduction of the fore-foot; moderate varus and equinus. The heel is well formed, but much elevated and cannot be brought to the ground. The inner border of the foot is concave and shorter as compared to the outer convex border; the cuboid, if hypertrophied and prominent, is only moderately so. The foot is somewhat smaller than its fellow, due to underdevelopment.

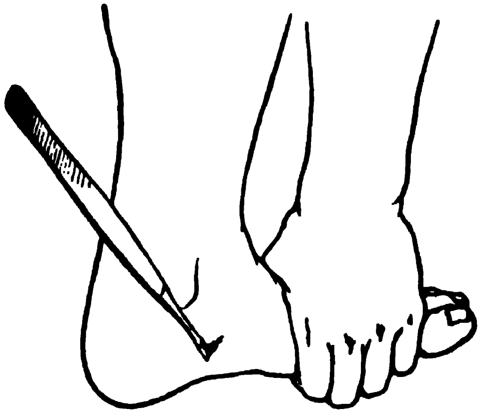

Fig. 18.—Illustrates Fasciotomy of Plantar Fascia at Its Posterior Insertion into the Os Calcis. The os calcis is the location of selection for this procedure, because there is a convergence of the fascia at this point. The proper position and direction of the tenotome is indicated.

Treatment of Group I.—TENOTOMY.—Certain cases of this type, in which the tarsus is largely in a plastic or cartilaginous state, respond readily to subcutaneous tenotomies and forcible correction, either manual or by the Thomas wrench. The sequence of subcutaneous tenotomies in these cases depends upon the severity and resistance to correction of the equinus and varus deformities. The more resistant deformity should be tenotomized first; that is, in a case where the equinus is more resistant, the tendo Achillis should be tenotomized and the heel forced down manually or by the Thomas wrench before the plantar fascia is divided, as in this way the benefit is had of the leverage of the unweakened foot.

The forepart of the foot is grasped by the surgeon's left hand and the tendo Achillis is put on tension by dorsal flexion of the foot. The blade of a small tenotome, held parallel to the tendon and to its inner side, is thrust through the skin and subcutaneous structures. The cutting edge of the blade is then turned posteriorly and the tendon is severed completely. Care should be taken to see that the plantaris tendon is also divided. This is evidenced by a sudden giving way and separation of the divided ends. After correction of the equinus, the plantar fascia is put on tension by forced dorsal flexion of the foot. The tenotome is thrust through the skin and subcutaneous structures on the inner side of the heel and just anterior to the insertion of the plantar fascia into the os calcis. The fascia is severed by cutting from within outward, and the foot is further wrenched in order to overcome the varus. Any other contracted bands resisting full correction are severed. It should be emphasized that, after wrenching, the foot should be entirely limp and permit overcorrection easily in all directions. Gauze dressings are placed over tenotomy wounds, and a plaster-of-Paris cast is applied from the toes to the groin, with the knee flexed to near a right angle and the foot well overcorrected.

At the end of 4 weeks, that part of the plaster-of-Paris dressing which is above the knee is removed, or the plaster-of-Paris is changed and another cast applied from the toes to the knee. Correction plaster-of-Paris casts should be worn for not less than 4 months, or as long as there is any tendency to relapse, as determined by discontinuing the casts for a short period.

BONE GRAFT WEDGE.—In the severer, or relapsing, cases of this group, when the tarsus resists correction by tenotomies and wrenchings, it is remodeled by placing a bone graft into the inner short or concave side of the tarsus at the point of its greatest concavity, which is at the scaphoid bone.

ALBEE'S TECHNIC.—In addition to preparing the deformed foot for operation, the leg is also prepared at the same time. A subcutaneous tenotomy of the tendo Achillis is done, and the equinus deformity is corrected. It is important that the heel should be thoroughly brought down, using the foot as a lever over the lower end of the tibia.

With the foot on a sand bag a U-shaped incision is made and a flap of skin and subcutaneous tissue sufficient to expose the inner aspect of the scaphoid is turned back. With a sharp osteotome the scaphoid is split into anterior and posterior halves. (See Fig. 19.) The correction of the adduction and varus deformities is accomplished by the forced separation and readjustment of the planes of the scaphoidal halves. While an assistant holds the foot in strong overcorrection, the distance between the scaphoidal halves is determined by calipers. The wound in the foot is then packed with a saline compress.

The crest of the tibia of the other leg is now exposed below the tibial tubercle, and a wedge graft is outlined in the periosteum by a scalpel, ⅛ to ¼ in. thicker than indicated by the caliper measurement of the scaphoid cavity previously taken. With the small motor saw, cuts are made along the periosteal incisions through the bone cortex. Before disengaging the graft from its bed, drill holes are made in its center with the motor drill. The graft is then removed by wedging a thin, narrow osteotome into the saw cuts, and is threaded on a strand of medium kangaroo tendon, each end of which is threaded into a strong cervix needle. One needle is forced through the anterior half of the scaphoid from the cut surface side by a strong needle-holder, and the other through the posterior half from its cut surface side. In older cases a drill may have to be substituted for the needle, on account of the density of the bone. The graft, which is slightly larger than the cavity in the scaphoid, is then forced into position between the two halves of the cut scaphoid, thus closing up the tarsal joints which have been separated anteriorly and posteriorly by the force exerted by the assistant in correcting the foot. (See Fig. 20 A, B.) The kangaroo tendon suture is then drawn taut over the graft and tied. The peri-osseous structures are drawn over the graft and sutured with chromic catgut, and the skin wound is sutured with plain catgut.

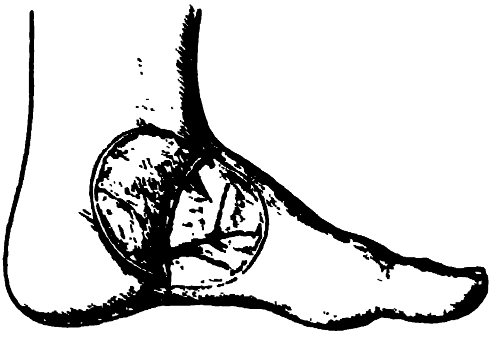

Fig. 19.—Exposure of Scaphoid or Astragaloscaphoid Joint for Insertion of Graft in Congenital and Acquired Club-foot. Dotted line indicates point for incision for scaphoid where graft is to be placed. Incision should be carried forward far enough so as to afford a flap to cover graft. (Albee's technic.)

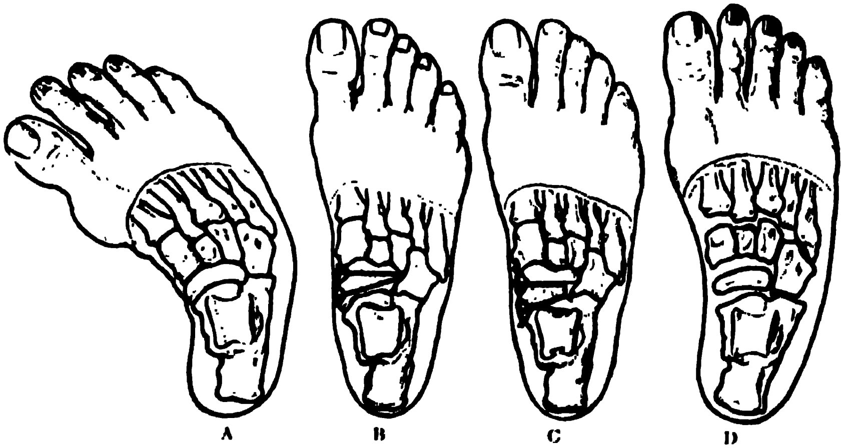

Fig. 20.—Congenital or Paralytic Club-foot—the Deformity and the Correction. A in diagram representing adduction deformity in congenital or paralytic club-foot, the scaphoid bone is split into interior and posterior halves. B shows the foot after osteotomy of the scaphoid and correction of adduction and varus deformity by the separation of the scaphoidal halves. A wedge cuboidal or tibial graft fixed with kangaroo tendon is represented in place. C indicates the cartilage removed from the posterior surface of scaphoid and the head of the astragalus in paralytic club-foot. A wedge tibial graft is represented in place. This increases the stability of the foot, at the same time it corrects the club-foot deformity. D represents the correction of a club-foot in an older child after the Phelps operation or any other purely soft tissue operation. The foot has been corrected by separating the tarsal bones on the inside of the foot at their joints. The danger of the subsequent closing up of these joints and a relapse of the deformity is obvious. (Albee's technic.)

With the foot overcorrected and the knee flexed to a right angle, a plaster-of-Paris cast is applied from the toes to the groin. This is allowed to remain on for 4 weeks, and is followed by a cast from the toes to the knee, for an additional 4 weeks.

Treatment of Group II.—In cases presenting a very short foot, more marked varus and a hypertrophied cuboid, the graft is taken from the posterior part of the cuboid on the outer side of the foot, and inserted into the scaphoid by precisely the same technic as that carried out in the tibial wedge graft. These incisions produce a complete transverse section of the bones of the tarsus and allow the forefoot to be not only swung outward at this point but to be rotated about the cuboscaphoidal ligament. As this ligament lies approximately equidistant from the inner border of the scaphoid and the outer border of the cuboid, it is the center of a circle of which a wedge taken from the cuboid is a sector, and when used to fill the gap formed by splitting the scaphoid and correcting the foot it exactly fits and at the same time the gap formed by its removal from the cuboid is closed.

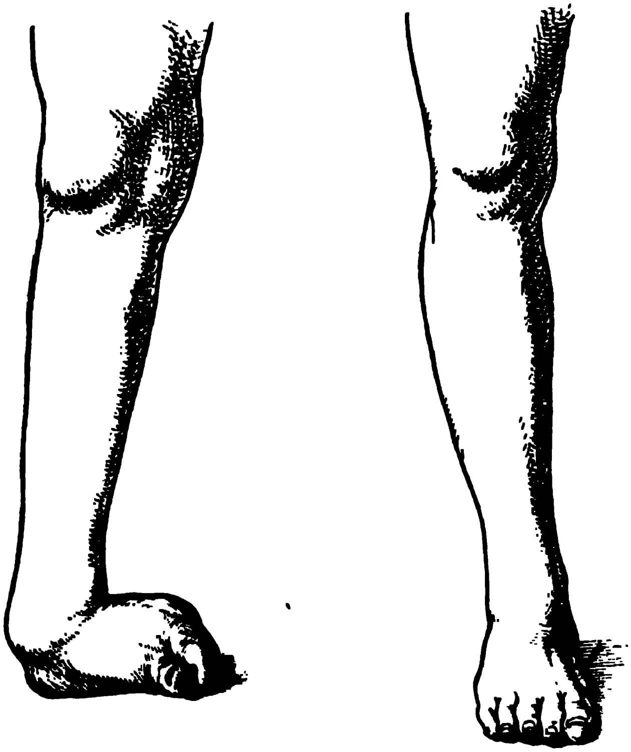

FIG. 21.—CONGENITAL CLUB-FOOT BEFORE AND AFTER INSERTION OF WEDGE GRAFT INTO THE SCAPHOID BONE. (Drawing from photographs.)

The foot and limb are fixed to the groin in a plaster-of-Paris dressing, with the foot well overcorrected and the knee flexed. This dressing should remain on for 4 weeks, followed by a second plaster-of-Paris dressing to the knee, to remain on 8 weeks.

Advantages of the Bone Graft in Club-foot.—It lengthens the foot, already much shortened. By permanently lengthening the short side of the skeleton of the foot it insures in a most trustworthy way against a relapse of the deformity. No joint is involved by the operation, therefore it does not cause an interference with joint function or mobility. (See Fig. 21.)

PARALYTIC TALIPES EQUINUS

Arthrodesis.—Arthrodesis is the operative treatment for talipes equinus. In order to support the foot properly, arthrodesis at the tibio-astragalar and mid-tarsal joints is necessary.

Under a tourniquet both of these joints are exposed by a median incision extending from about 1 in. above the ankle-joint downward for 3 in. The cartilage is removed from the astragalus and leg bones and the astragaloscaphoid (see Fig. 22), also the calcaneocuboid articulations, with an osteotome or knife. The approach of these joints is much enhanced by plantar flexion. A dressing of shaken gauze and a plaster-of-Paris bandage holding the foot at a right angle are applied.

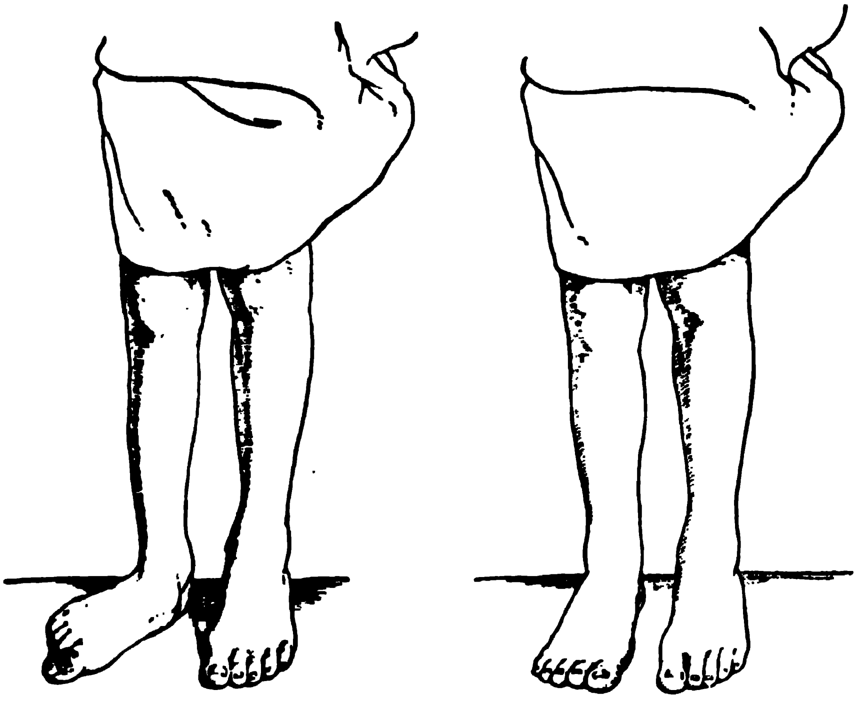

FIG. 22.—AN EXTREMELY PRONATED FOOT CORRECTED BY AN ARTHRODESIS OF THE ASTRAGALOSCAPHOID JOINT. (Soule's technic.)

This operation should only be done for paralytic equinus, after a sufficient period of fixation of the foot at a right angle to determine that there is no possibility of any recovery of tone of the flexors of the foot on the leg.

ACQUIRED CLUB-FOOT

Paralytic Varus.—This type of deformity is due to unbalancing of the foot by paralysis or weakening of the peroneal muscles. The outer border of the foot drops, the fore-foot adducts, and the child walks upon the outer edge of the foot, forcing it into further adduction, and causing an increasing hypermobility at the astragaloscaphoid joint, resulting in a deformity very similar to that of a congenital club-foot. The requirements for treatment are very similar to those of congenital club-foot, with the addition, of necessity, of the control of the hypermobility and dropping of the outer border of the foot.

ALBEE'S OPERATION FOR PARALYTIC VARUS.—The tendo Achillis is tenotomized, if shortened. The astragaloscaphoid joint is reached by a U-shaped incision and the turning up of a flap of skin and subcutaneous tissues. With a sharp chisel or osteotome, all the cartilage is removed from the posterior surface of the scaphoid and the head of the astragalus. The foot is overcorrected and the anteroposterior diameter of the cavity is taken between the cut bone surfaces of the scaphoid and astragalus. The wound is packed with hot saline compress. The tibia is laid bare about 3 in. below its own tubercle. The dimensions of the required graft are outlined by a scalpel in the periosteum. With the small motor saw, cuts are made completely through the bone cortex. With the motor drill 2 holes are drilled through the cortex of the graft, before it is disengaged from the tibia. The transplant is then removed from its bed with a chisel and threaded upon 1 or 2 strands of kangaroo tendon, the ends of which are threaded into strong cervix needles. One needle is forced through the inner border of the scaphoid from the cut surface side, and the other is passed through the inner surface of the head of the astragalus from the cut surface side. The graft is pushed into position between the astragalus and the scaphoid, the sutures drawn tight and tied over the graft. (See Fig. 20.) The peri-osseous tissues are drawn over the graft and sutured with chromic catgut and the skin wound is closed by continuous plain catgut suture.

If the peroneal muscles are entirely paralyzed, the varus or dropping of the outer side of the foot can best be controlled by using the tendons of those paralyzed muscles for ligaments, as suggested by Gallie. The peroneal tendons and external malleolus are exposed by a curved incision with its convexity posterior. An osteoperiosteal flap, 1 in. in its vertical diameter and 2/3 in. in its anteroposterior diameter, is turned posteriorly by a chisel on the peri-osseous and periosteal tissues as a hinge. The peroneal tendon sheaths are split for a considerable distance up and down from opposite the periosteal flap, and the tendons are brought forward and placed beneath the osteoperiosteal flap, which is sutured over them with silk. Additional silk sutures are passed through the upper and lower edges of the osseous flap, through the tendons, and into the periosteum and periosseous tissues of the fibula beneath the tendons.

It is important that the foot is held in overcorrection and that the tendons are held taut while the sutures are placed in position. The skin wound is closed by continuous catgut sutures. With the foot held in overcorrection, and the knee flexed, a plaster cast is applied from the toes to the groin. This plaster should be removed at the end of 4 weeks and be replaced by another reaching from the toes to the knee for an additional 6 weeks. It should be determined in individual cases whether additional support by braces is needed.

If it is not desirable to use the peroneal tendons for ligaments because the muscle power is not entirely lost, silk ligaments may be inserted between the tip of the external malleolus and the cuboid, to fortify the weakened muscles. This is best accomplished by short incisions over the external malleolus and cuboid, the silk ligaments being passed under the skin by tunneling with a blunt-eyed probe or a broad ligament clamp. The ends are inserted into the bones of the external malleolus and cuboid by strong cervix needles or by drilling. As there is danger of the untying of knots of heavy silk, fine silk is tied around each half knot.

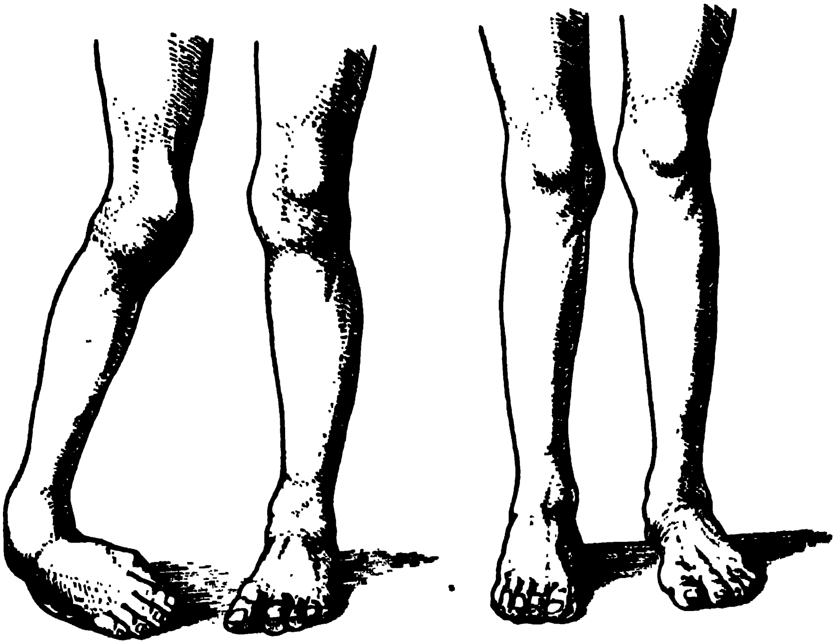

Fig. 23.—Case of Paralytic Club-foot Before and After Operative Correction by Bone Graft Wedge between Head of Astragalus and Scaphoid. (Albee's technic.) Drawings from photographs.

Postoperative convalescence is carried out in precisely the same manner as when the tendons are used for ligaments.

Advantages of the Albee Method.—Adduction and varus are corrected. The adduction is overcome by lengthening the inside of the foot and fixing the scaphoid to the astragalus by the mechanics of a wedge. Hypermobility is controlled and a stable foot is produced. The mechanical balance of the foot is much improved. The anterior tibial muscle, an active factor in producing the deformity, is restored to its normal function. In certain cases, when the anterior tibial is well developed and the peroneal muscles are paralyzed, the adduction of the foot is overcorrected by inserting a larger bone wedge graft; the anterior tibial muscle is thus made to do more than its normal work by overbalancing the foot.

Talipes Equinus.—This is due to the paralysis of the dorsal flexors and a consequent shortening of the plantar flexors, namely, the gastrocnemius and soleus muscles. To correct this deformity, it is sufficient to do a subcutaneous tenotomy of the tendo Achillis and plantaris tendons near their insertions into the os calcis by the technic previously described under club-foot.

Talipes Calcaneocavus.—Deformity of the foot of this type includes both anterior and lateral displacement. Paralysis of the calf muscles is the essential cause. The distortion develops from functional use. The os calcis, unrestrained by the calf muscles, tips on end and increases the distance between the ankle joint and the weight-bearing portion of the heel. The foot is shortened, and the arch is increased, and added to by the pull of the plantar flexors.

The characteristic feature of a foot of this type is its insecurity which, with the deformity, centers about the astragalus. The removal of this bone, as recommended by Whitman, causes both the cavus and the lateral distortion to disappear, and the resultant loosening of the tissues allows the foot to be displaced backward and the plantar to be flexed in the equinus. The lateral deformity is prevented by the malleoli gripping the anterior ends of the os calcis, and the return of the calcaneus is prevented by the impingement of the scaphoid against the anterior surface of the lower end of the tibia. The replacement of the foot so increases the leverage that the transplanted peroneal muscles are able to functionate with unusual efficiency.

OPERATIVE TECHNIC.—The technic, as described by Whitman, is as follows: An Esmarch bandage having been applied, an incision is made from a point about 1 in. down the external malleolus, midway between it and the tendo Achillis, passing downward to the attachment of the tendo Achillis, forward below the extremity of the malleolus, and over the dorsum of the foot to the external surface of the head of the astragalus. The sheaths of the peronei tendons, which are exposed, are opened, the tendons divided below the malleolus and drawn backward. The bands of the external lateral ligaments are next divided, and the foot being somewhat adducted, the intra-osseous ligament is separated. On further inversion, the tissues being retracted, one may, with the scissors, free the head of the astragalus from its attachment to the navicular and, forcibly twisting it outward, break off the cartilaginous margin to which the internal and posterior ligaments that cannot be reached are attached. The new articulation is then prepared.

A thin section is removed from the lateral aspect of the adjoining os calcis and cuboid bones and from the internal surface of the external malleolus, which may be further shaped to secure accurate apposition. The same, but more difficult, procedure is undertaken on the opposite side. The internal lateral ligament is separated from the malleolus thoroughly, in order to permit complete backward displacement, and the cartilage is then removed from its inner surface. With a periosteal elevator, the strong inferior calcaneonavicular ligament is detached sufficiently to permit the malleolus to sink in behind or to slightly overlap the navicular. The two peronei tendons, thoroughly freed from their attachments to the fibula, are then passed through the base of the tendo Achillis from within outward, and are sutured to it and to the periosteum of the os calcis as well, at a sufficient tension to hold the foot in moderate plantar flexion. The tendo Achillis is sometimes overlapped and sutured, as an aid in restraining deformity. The malleoli are then forced forward and accurately adjusted in the new articulation, and the wound is closed with catgut, reinforced with several silk sutures. The foot, carefully supported in its attitude of backward displacement (see Fig. 21), and moderate plantar flexion, is thickly covered with sterilized sheet wadding and fixed by a light plaster bandage, particular care being taken to exert only the slightest constriction. The Esmarch bandage is then removed. The leg is then brought to a right angle with the thigh and the plaster bandage is continued over the thigh. The limb is suspended for several days or a week, the aim being to relax tension and lessen congestion. The plaster bandage, fixing the limb in flexion at the knee, remains for several weeks, until immediate repair is complete, a section being removed from over the wound for inspection at the end of a week. It is then replaced by one reaching only to the knee, holding the foot in moderate plantar flexion, the sole being made level by the insertion of a wedge of cork. The plaster support is worn for about 6 months—the longer the better since the patient must bear weight on the front of the foot.

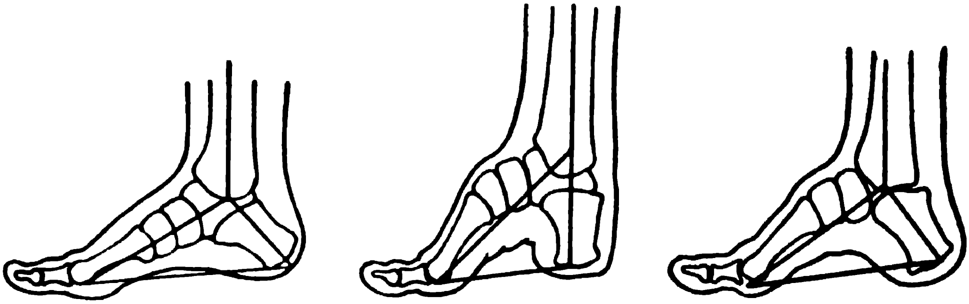

Fig. 21. First Drawing Shows Normal Leverage of Foot. Second Shows Faulty Balance of Calcaneocavus Foot with Heel Much Shortened. Third Shows Astragalus Removed and Stability and Normal Leverage of Posterior Part of Foot Partially Restored. (After Whitman.)

Although the cartilage is removed from the malleoli and adjoining bones, ankylosis never follows. In certain unfavorable cases, a brace may be applied to hold the foot in equinus for a longer period of time.

TUBERCULOUS OSTEITIS OF THE SHOULDER

This disease, here as elsewhere, is treated by rest, which is best accomplished by fixing the wrist to the neck by a sling, with the elbow at a right angle.

The thorax, axillary space, and shoulder are well padded with cotton wadding. With the arm to the side, the thorax, shoulder, and arm are included in a carefully moulded plaster-of-Paris dressing.

Another method of fixation, suggested by Soule, consists of the application of a plaster-of-Paris cast to include the chest, diseased shoulder, arm, and hand. The arm is held flexed at a right angle and away from the chest wall, to enable the patient's clothing to be put on. As a lining to the cast, stockinette or a jersey shirt is used, and padded by the use of Shaker flannel bandages over bony prominences. The dressing, well fitted, furnishes a most efficient fixation and comfortable method of treatment.

CONGENITAL ELEVATION OF THE SCAPULA

Conservative Treatment.—The milder cases are overcome by passive motion and exercises planned to correct the restriction of abduction of the arm and elevation of the shoulder. These measures are not likely to correct severe cases when the elevators of the scapula are contracted or when there is a bony bridge connecting the scapula to the vertebra. In these latter cases, it is obvious that an open operation is necessary.

Operative Technic.—A vertical incision is made through the skin and fascia between the spinous processes and the scapula. The contracted muscles, which are usually the levator anguli scapulæ and the rhomboides major and minor, are divided, together with any shortened fascial bands which prevent the normal replacement of the scapula. If a bridge of bone exists between the scapula and vertebræ, it is carefully removed, together with any other supernumerary plates of bone or fibrous tissue. If any portion of the scapula overrides the spinous processes, or if the superior portion hooks over the apex of the shoulder, these portions should be resected in order to facilitate the reposition of the scapula. If any difficulty is met with in holding the scapula in position, it may be anchored to a rib below by means of a temporary ligament of kangaroo tendon.

The skin wounds are closed by a continuous catgut suture, the elbow is fixed to a right angle, the arm abducted to 90° and fixed by a plaster shoulder cises, both passive and active, are practiced for a few weeks until motion is spica from umbilicus to wrist. The cast is left on for 4 weeks, and then exer-
free.

TUBERCULOUS OSTEITIS OF THE ELBOW

The treatment of this disease, here as elsewhere, is rest. The arm should be fixed at right-angle flexion, which is the position of greatest usefulness in case of ankylosis or limited motion. This is best accomplished by a plaster-of-Paris splint from the axilla to the wrist. In very acute cases, it may be necessary to include the hand in the plaster-of-Paris.

TUBERCULOUS OSTEITIS OF THE WRIST

Here, as at the elbow, treatment consists in functional rest, with the wrist in an attitude which will give the patient the least inconvenience if ankylosed or limited in its motion. The wrist should be placed in moderate extension, as this will allow the best closure of the hand by the action of the flexor muscles. Plaster-of-Paris affords the best means of fixation.

PARALYTIC DROP WRIST

This deformity, usually resulting from infantile paralysis, is a most incapacitating one, in that it causes a loss of the grasp and prevents the flexor muscles from closing the hand. Apparatus for the control is inefficient and awkward. If there is any evidence of contractility in the extensor muscles, hyperextension should be maintained and the use of massage and electricity should be resorted to. When these muscles are entirely paralyzed, a transplantation of the flexor carpi radialis and ulnaris has been recommended. The prognosis of this procedure is questionable and it should be attempted only in the most favorable cases. A much more trustworthy procedure is that of fixing the carpus in moderate dorsal flexion by a tibial bone graft.

Albee's Operative Technic.—The posterior aspect of the distal ends of the radius and adjacent part of the carpus are exposed by turning up a flap of skin and subcutaneous tissues. With the Albee motor twin saw, a gutter is made in the posterior aspect of the radius about 1½ in. long and about 1½ in. from its distal end. The wound is packed with saline compresses. With the same motor twin saw, a graft of sufficient length is removed from the antero-internal surface of the patient's tibia. This transplant is then inserted into the radial gutter and held with kangaroo tendon in drill holes, and sutured under the ligaments on the posterior aspect of the trapezoid and os magnum. The subcutaneous tissues are drawn over the graft and sutured with interrupted sutures of chromic catgut. The skin wound is closed with interrupted sutures of horse hair.

The forearm and hand are included in a plaster-of-Paris bandage which is worn for 3 weeks, followed by a second splint for 5 weeks. Arthrodesis may be done in place of the bone graft procedure, in individuals over 12 years of age.

TREATMENT OF SCOLIOSIS (ROTARY LATERAL CURVATURE OF THE SPINE)

In considering the treatment of scoliosis, we feel called upon to state that although we believe a long stride has been taken toward the solution of this difficult problem in the past few years, yet the final solution is by no means reached.

Abbott's Method.—Abbott has produced excellent results by his method, and has stimulated orthopedic surgeons to new energy in dealing with this deformity. He compares scoliosis to club-foot, and maintains that, as in the treatment of club-foot, permanent correction requires fixation in an overcorrected position sufficiently long for the readjustment and reshaping of the structures involved. He claims that lateral curvature requires, for its permanent correction, the production of a curvature in the opposite direction and the maintenance of this overcorrection long enough to prevent a relapse to the original deformity. He accomplishes this overcorrection by placing the patient upon his back in his specially constructed frame in a hammock of canvas so shaped as to allow the spine to flex, and at the same time to permit the concave side of the thorax (the pelvis being fixed) to be forced posteriorly and laterally by means of bands drawn about the trunk and fastened to the various windlass bars of the frame.

With the patient held in this fixed and overcorrected position in the frame, a strong plaster-of-Paris jacket is applied—well padded over bony prominences. An excess of padding is applied over the flat side of the posterior aspect of the thorax in the region of the large plaster window. This padding is for the purpose of causing the edges of the large plaster window to flare and is removed later to allow further correction.

When the jacket has hardened sufficiently, the patient is removed from the frame and a large window is cut in the jacket posterolaterally over what was the concave side of the curvature, and smaller ones anterolaterally on what was the convex side, through which thick felt pads are introduced to further force the thorax posterolaterally through the large oval window in the jacket.

These jackets are changed every 4 to 6 weeks, until full overcorrection is obtained; then a celluloid jacket is applied, to be removed for taking prescribed exercises, and to be worn until all tendency to a return to the former deformity is overcome. The length of time required varies with the location and severity of the deformity. It must here be acknowledged that not all cases are amenable to this method of treatment, or to any other method. It is important that treatment should be begun at the earliest possible period of the deformity.

Forbes' Method.—Forbes advocates rotation of the thorax toward the convex side, as well as flexion and fixation in a plaster-of-Paris jacket, fenestrated similarly to the Abbott jacket. From his reasoning and experiments, we consider his contribution toward the solution of this problem of much value. He has also devised a special apparatus for applying his plaster jackets in flexion and rotation. His method of rotation of the thorax brings a leverage action of the ribs at their attachment to the posterior segment of the vertebræ to force an actual rotation of the vertebræ, an increase in the angle of the ribs of the flattened or concave side, a widening of the angle of the ribs of the convex side, and a restoration of symmetry of the chest wall. He points out the fallacy of using direct pressure against the ribs of the convex side of the thorax in forcing the correction of the curvature, showing by his accompanying diagram that by this procedure the rotation of the vertebræ toward their corrected position does not take place, but, instead, this lateral pressure actually tends to further rotate the bodies toward the convex side, sharpen the angle of the ribs of the convex side, and further flatten the chest wall of this side.

The reason for this increase of rotation of the vertebræ toward the convex side is that as the ribs have their attachment to the vertebræ posterior to the normal center of rotation of the spine, any pressure brought to bear upon this posterior segment—either directly or indirectly, as through the ribs laterally—forces this posterior segment to rotate away from, and the anterior segment—or the bodies themselves—toward the convex side. This lateral pressure exerted to the convex side of the thorax is transmitted to the ribs of the opposite or concave side through the interposed sternum, tending to widen the angle of the ribs of the concave side and by their leverage action on the posterior segment of the vertebræ of the concave side to pry this posterior segment toward the concave side and assist the bodies of the vertebræ to rotate toward the convex side. Forbes' method of applying the plaster jacket differs but little from that of Abbott. While Abbott's method is essentially flexion and lateral pressure on the spine, Forbes' method is torsion and flexion of the spine.

(Paralytic Scoliosis, see 179.)

THE INLAY BONE GRAFT FOR TREATMENT OF UNUNITED FRACTURES

Objections to Other Methods. The Lane plate and other internal metal splints, when applied to ununited fractures of long standing, are a hindrance rather than an advantage in securing bony union. In ununited fractures we have in the ends of the fragments a marked diminution or an entire cessation of osteogenetic activity. This cessation of activity is evidenced in the marked sclerosis or eburnation which is always found in ununited fractured ends, often extending back from the seat of fracture for from ¾ to 2 in. The pathology of this condition of sclerosis is very similar to that found in non-ankylosing osteo-arthritis, where there are an overdeposit of calcium salts and a consequent diminution and degeneration of bone-producing cells.

The therapeutic requirements of these pseudo-arthroses are fixation, stimulation of osteogenesis on the part of the fragments, and an osteogenetic scaffold connecting the active bone in each fragment back of the eburnated areas.

The bone graft, when inlaid according to the technic herein described, is the only means of fulfilling these requirements. Two, if not all, of these three essentials are necessary in order to secure union. The Lane plate furnishes but one of these, viz., temporary fixation, but at the same time it causes absorption and disintegration of bone. The bone transplant not only produces fixation but also stimulates callus-formation and grows bone on its own part.

Abundant evidence has accumulated to prove that something more than fixation is necessary in these conditions. The most favorable cases for external fixation, such as fractures at the middle third of the tibia, with the fibula intact, have failed to unite in spite of months of effectual splinting and recumbency in bed. At operation no interposition of soft tissues appeared and there was no evident reason for non-union.

Codivilla appreciated the above-mentioned therapeutic requirements and met them partially by spanning the fractured area with a very thin autogenous periosteal graft, which gave a fair percentage of good results. But it was not an ideal procedure in that it did not furnish efficient fixation, it did not stimulate osteogenesis between the end of the fragments because it was entirely superficial, and it did not penetrate cortical bone structure. Being extraosseous, it therefore furnished an imperfect graft environment.

Murphy has evolved a better method in his use of an intramedullary dowel, which furnishes more effectual fixation and, being entirely intra-osseous, favors stimulation of osteogenesis by better contact of graft to recipient fragments. It is, however, difficult to get contact of graft to active bone beyond the sclerosed area, which is most important. It is also difficult of application in fractures of the ends of bones where there is no medullary canal, and in small bones, such as those of the forearm, where the medullary canals are small. As in the case of the intramedullary aluminum splint of Elsberg, it is most difficult to secure the necessary lateral fixation in fragments in such cases as fractures of the ulna and radius, where these bones have been contractured together during long-existing non-union.

An illustrative case that will be mentioned later was that of an ununited fracture of 4 years' duration at the middle of the radius. After 4 unsuccessful operations, including Lane plating, the radial fragment ends were found closely contractured to the side of the ulna. They were freed with difficulty and held in proper alignment by a long inlay bone graft. On account of the strong tendency of the angulation to relapse, the necessary lateral fixation would have been impossible by any intramedullary splint. The problem was easily solved by the leverage action of a long inlay bone graft. It is always difficult to get a tight fit of the intramedullary splint into both fragments.

Albee's Technic.—The technic applied in ununited fractures of long bones is as follows: The fracture is exposed by a generous skin incision. When the fractured bone is superficial, as in the case of the tibia, the incision is made lateral to the intended site of the bone insert. The skin and subcutaneous tissues are retracted, the bone ends are developed and freshened with chisel, motor-burr or saw, and the sclerosed bone plug is removed from the medullary canal.

If there is overlapping of the fragments, the amount of pull required to correct it varies with the degree of overriding at the site of fracture. In the case of a fractured femur in a muscular man as much as a 150-pound pull may be necessary to secure sufficient extension. In this instance, it is far better to set up and adjust a traction pulley apparatus with heavy weights, or use the Hawley fracture table—either provides a constant and uninterrupted pull. If the fragments still overlap and sufficient extension cannot be made to bring them together, it is necessary to trim off the fragments with motor-burr, saw, or chisel, until good position can be secured. This will produce shortening, but it cannot be avoided.

The fragments are now held in good alignment by an assistant. The periosteum is divided with a knife longitudinally over the bone to be removed in making the gutter for the bone insert. The periosteal flaps are turned back to either side, exposing the bone.

Two parallel saw cuts, about ⅜ in. apart, are made longitudinally to the fragment ends completely through the bone cortex to the marrow cavity, with a motor twin circular saw (see Fig. 1). The distance between the saw cuts is arranged by adjusting the distance between the twin saws. These cuts are made from 2½ to 3 inches into the end of each fragment from the line of fracture, while the fragments are held in good alignment. They should always extend far enough from the line of fracture to reach well into the non-sclerosed, active bone of either fragment. This distance is subject to considerable variation, depending upon the site of fracture and the amount of eburnation present. The twin saws should be adjusted so that the width of the gutter for the graft should be from 5/16 to 8/16 in., according to the size of the bone. The revolving saws are kept constantly bathed in saline solution by a spray connected with a sterile tube to a fountain syringe. This prevents the development of excessive heat from friction, which should always be avoided on account of its devitalizing effect upon peripheral bone cells.

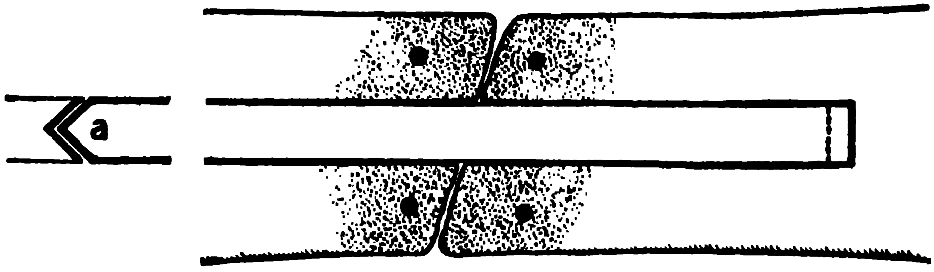

Fig. 25. —Diagram Illustrating Ununited Fracture of Long Bone with Inlay Graft in Place. The dotted areas in the end of each fragment represent the bone sclerosis which is present in every ununited fracture, existing for any length of time. The four holes are for kangaroo tendon for the purpose of holding the center of the inlay. (See cross-section, Fig. 26.) The dotted lines at each end of the inlay and the drawing (a) of sagittal section of the end of the graft and the cortex at end of gutter illustrate the tongue and groove means of fixing the ends of graft, used in certain cases, especially where a loss of bone substance has occurred.

After the twin saws have traveled the desired length to make the gutter for the graft, the bone fragments between the saw cuts are removed by severing the ends distal from the point of fracture with a narrow osteotome in such a manner as to effect a tongue and groove joint with the ends of the graft (see Fig. 25). With a motor-driven drill, holes are bored in the cortex on either side of the gutter, slanting inward to the marrow cavity, if kangaroo sutures are to be the means of holding the graft in place. These holes are placed near the line of fracture, so as to fix the center of the insert. The ends of the graft are secured in position by the above-mentioned tongue-and-groove joint, when feasible, or by additional sutures. This joint is very quickly shaped, and the greater the muscular contracture the more securely it is held in place.

The exact length of the desired insert is obtained by measuring the gutter and transferring this measurement to the exposed antero-internal surface of the opposite tibia. A flexible probe or mechanic's calipers is usually satisfactory for this purpose, a right-angled bend marking the exact measurement.

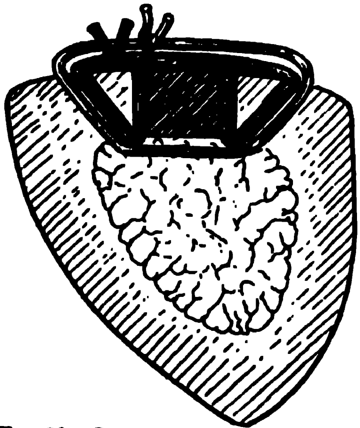

FIG. 26.—DRAWING SHOWING INLAY GRAFT FOR FRACTURE OF TIBIA OR OTHER LONG BONE HELD IN PLACE BY TWO STRANDS OF HEAVY KANGAROO TENDON. Kangaroo tendon is placed at each end of graft and in ends of fragments near center of inlay.

The wound and gutter are packed with hot saline compresses while the graft is being prepared. The patient remaining in the dorsal position, the graft-yielding tibia is exposed by an incision over its crest. The overlying structures are retracted, and the size and shape of the graft are outlined in the periosteum by means of the scalpel, with the probe measure as a guide. With the twin saws adjusted to the same distance apart as when forming the gutter, bone cuts are made to the marrow cavity along the antero-internal tibial aspect. With a narrow osteotome or small motor-driven saw or burr, the graft is now dislodged and the ends grooved with the motor-saw to fit the triangular tongue of the gutter ends.

A double strand of heavy kangaroo tendon is passed through the drill holes previously made. One strand in each fragment is now pulled up from the bottom of the gutter, and the graft is placed under them. (See Fig. 26.) Traction is now exerted on the limb and the graft is forced into position. A good fit is assured, because the same adjustment of twin saws is maintained both in forming the gutter and in removing the graft, and therefore they must be of equal and uniform width throughout their whole extent. Traction is now removed, and the elasticity of the soft parts forces the tongue-and-grooved ends into tighter adjustment. The kangaroo fixing sutures are then drawn taut and tied over the graft.

It is readily seen that this not only affords most effectual fixation but that it also furnishes a most ideal environment for the bone graft. It brings each structural layer of the bone graft into close apposition with its corresponding layer in the recipient fragment, namely, periosteum to periosteum, cortical bone to cortical bone, endosteum to endosteum, and marrow substance to marrow substance. Periosteum and—when possible—endosteum and marrow substance are always included in the graft. We have proved by animal experimentation that this close contact of Haversian systems assures permanent viability of a large portion of the insert. The bone which has been removed from the ends of the graft in order to form the above-mentioned grooves, and other normal bone fragments, are finely chipped with a rongeur and pushed between and placed about the ends of the fragments at the line of fracture wherever possible. These act most effectively as supplementary foci of osteogenesis. Macewen has well pointed out that the efficacy of a bone graft varies in inverse ratio to its volume. The smaller the graft, the greater the relative osteogenesis.

The site of the fracture is covered with the periosteal flaps which were reflected to expose the bone to be removed. This gives two layers of periosteum covering the transplanted fragment. The overlying tissues and skin are closed without drainage. The leg wound is closed in a similar way, except that the adjacent muscles are drawn into the cavity from which the graft was taken. Splints are applied and not removed before five weeks.

ILLUSTRATIVE CASES

Case I.– M. S.; female; 45 years old; always healthy. Four years previously she fell, fracturing the right radius at the junction of the middle and distal thirds, the ulna remaining intact. Fragments reduced under ether. No union occurring in 8 weeks, the fracture was cut down upon and the muscle freed from the bone ends. Good apposition was secured, but no union followed. A second open operation was performed, and the fragments were nailed together. Again no union resulted. At a third open operation, the fragments were wired, but again no union followed. Two years after the fracture, at a fourth operation, Lane plates were applied, and this also was followed by non-union. Two years later 4 years after the fracture the patient, in desperation, consulted me to determine whether something further could not be done, for her arm was both painful and useless.

November 7, 1913, the fracture was cut down upon and the Lane plate was found loose in the periosseous tissues. The tips of the screws were found in large circular cavities in the bone from which they had loosened. There was a depression in the side of the fragment ends where the metal plate had caused an absorption of bone. The radial fragments, as shown in Figures 3 and 4, were much shortened from the previous operations and the metal contact, and badly angulated toward the ulna. Their ends were made fresh and with much difficulty their alignment was corrected. This caused the radial fragments to retract from each other about an inch. The periosteum on the outer side of each fragment was incised distally from the fracture for 2½ in., and retracted, exposing the bone.

By means of the motor saw and osteotome, a gutter was made in the fragments, according to the technique described, about 3/16 in. wide and 3½ in. long. With the motor saw, a graft 3½ by 7/16 by 3/16 in. was removed from the antero-internal aspect of the tibia and trimmed with the saw so that it fitted tightly into the gutters in each fragment. The strong tendency of the angular deformity to relapse was prevented, and the fragments were held very securely by the heavy kangaroo bone suture previously described. A plaster-of-Paris cast was applied and upon its removal, 5 weeks later, firm union of the fragments had occurred in good position (see Fig. 6).

Case II.—H. C.; male; 28 years old; in an automobile accident in Scotland, April 5, 1911, sustained a fracture at the middle third of the right tibia and fibula. The fracture was reduced and placed in a plaster-of-Paris splint. Seven weeks later, no union had occurred, and Bier's hyperemia was applied for 4 months at a hospital in Scotland. No union resulted. One year after the fracture, with non-union, I cut down on the tibia and inlaid a graft 5 in. long, according to the above-described technic.

It was not deemed necessary to disturb the fibula. In 5 weeks, firm union had occurred. Excellent function existed 20 months after the operation.

FRACTURES OF THE VERTEBRÆ

In cases of non-union and certain fresh fractures of the vertebræ when displacement and cord pressure have not occurred, the bone graft, as applied by me in Pott's disease, is applicable for support and fixation.

Illustrative Case.—An illustrative case is that of a young woman referred by Dr. H. E. Johnson of Naugatuck, Conn. She sustained, in a railroad accident, a horizontal fracture through the middle of the body of the eleventh dorsal vertebra. Plaster-of-Paris jackets were worn continuously for 1 year, at the end of which time support was so necessary that whenever the casts became soft the patient complained of pain and lack of support, and asked for a fresh jacket. The tips of the tenth, eleventh, and twelfth spinous processes were exposed through a circular incision to the right, turning up the flap of the skin and subcutaneous tissues. These spinous processes were split en masse with the attached supra- and interspinous ligaments with a scalpel, thin chisel, and mallet. A graft of sufficient length was removed from the crest of the right tibia and inserted in the cleft. The split ligaments, with the imbedded fragments of the spinous processes, were drawn over it by means of interrupted sutures of medium-sized kangaroo tendon. The patient was kept on a fracture bed for 5 weeks. The support from the graft thus embedded gave immediate relief, although no plaster-of-Paris jacket was applied. At this writing, there is no pain or evidence of lack of support.

UNUNITED FRACTURE OF NECK OF FEMUR

In cases of ununited fracture of the neck of the femur, the bone graft is even more advisable than in the shafts of long bones, for here the mechanics, blood supply, and osteogenetic conditions are much more unfavorable to union. This is exemplified by the case of a young woman who received a fracture of the neck of the femur, and four months later non-union was evident. The pseudarthrosis was cut down upon, the ends of the fragments were freshened, and the fragments were held together by a long square tin-plated spike driven through the great trochanter and neck into the head. A long plaster-of-Paris spica was worn for 10 weeks. Primary union of the soft tissues resulted and the convalescence was uneventful. Much bone absorption about the spike occurred, and non-union resulted.

This experience, among others, has induced me to evolve the following technic for the application of the bone graft in place of the metal spike:

Illustrative Case.—Female, 60 years old; non-union of the neck of the femur, of 5 months' duration. The point of fracture was reached through an anterior incision from the anterior spine of the ilium downward for 5 inches. The ends of the fragments were freshened by chisel and sharp curet. A point just below the great trochanter was reached by a short lateral incision. The proper location through the center of the neck and the direction of the drill hole for the graft were determined by thrusting a small hand drill through the great trochanter obliquely upward through the center of the neck and into the center of the fractured end of the capital fragment, as felt or seen through the anterior incision. (This may necessitate the withdrawal and reinsertion of the drill.) When the proper location and direction for the drill hole were determined, the large motor-driven drill was pushed inward along the direction previously determined, through the center of the neck and well into the head. This drill, made after my directions, produced a hole 6/16 in. in diameter. The drill was then disengaged from the motor and left in to hold the fragments in apposition while the bone graft was being removed from the crest of the opposite tibia.

This graft was removed by the motor saw, and was about 4 in. long by 6/16 to 7/16 in. in cross section. My doweling instrument, which turns out a dowel of proper size to fit the drill hole, was then adjusted into the motor (see Fig. 6). While the motor was held on the table by an assistant, I fed the graft slowly into the doweling instrument. This was done with comparative speed and assured a proper fit, as the doweling instrument corresponds accurately in size to drill. This strong graft was driven into place by a metal mallet. The operative technic being similar to that when the metal spike is used. The skin was closed without drainage. In 6 weeks there was firm union. Six months after operation the patient walked about without pain and with perfect function.

The inlay bone graft, as applied in pseudarthrosis, herein mentioned, has given 100 per cent. of bony union.

On account of the eburnation which always exists in the ends of fragments in cases of pseudarthrosis, it may be essential to use healthy bone from elsewhere in the body, as the tibia.

INLAY BONE GRAFT IN FRESH FRACTURES

In cases of *fresh fracture*, however, as the bone is osteogenetic, material can be taken from the fragments themselves and used to advantage. This is best done by making the saw cuts in one fragment just double the length of the other and transposing the two strips of bone removed.

This has been done in two of my later cases of pseudarthrosis and in all cases of recent fresh fractures; the inlay graft as well as its gutter site has been so formed that they are about ¼ in. wider at their periosteal surface than at their endosteal surface. This wedge-shaped cross-section of graft and its gutter prevent the graft from slipping into the marrow cavity. This is of especial advantage in all operable cases of fresh fracture, because the medullary canal is never filled by new bone as is the case in long-standing non-union. The graft is held in place by autogenous dowel grafts placed obliquely into the cortical bone on either side of gutter with their ends projecting over and in contact with the periosteal surface of the graft. (See Fig. 27.) This affords a fixation practically as secure as that of the Lane plate and without the use of any foreign substance. The grafts are removed from the fragments by starting the cuts with the twin motor-saw adjusted to about 7/16 in. (11.1 mm.) apart in a femur, then completing the cuts through the cortex to the marrow cavity with a single motor saw. The longer strip of bone is then inserted into the gutter so that half of it is in one fragment and half in the other.

Dowels are now turned out with the motor doweling instrument, using for this purpose either the shorter strip of bone or bone removed farther distal from point of fracture.

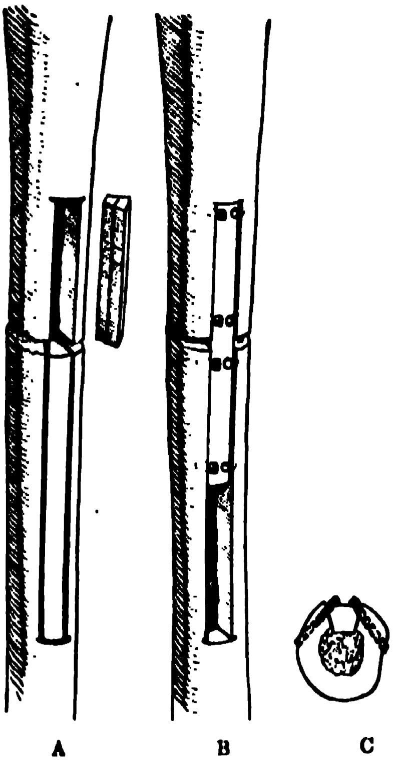

FIG. 27.—DIAGRAMMATIC ILLUSTRATION OF ALBEE'S INLAY BONE GRAFT METHOD IN THE TREATMENT OF FRESH AND UNUNITED FRACTURES. The shorter piece of bone lifted from the gutter is split longitudinally with motor saw into two or three parts, from which dowel pegs are made by electric lathe. Drawings B and C illustrate graft held in place by graft pegs, also cross-section of gutter and graft.

The graft is then forced into place and 4 holes drilled obliquely to its side into the cortex of the gutter. The dowels are then driven into place, allowing their ends to project over and in contact with the periosteal surface of the graft. The inlay graft thus inserted affords as secure immediate fixation as the Lane plate.

This, as well as other similar technic, would be difficult without resorting to the motor saw. The proper use of the motor saw, by shortening the time of operation, lessening the traumatism, and affording a means for accurately shaping the bone grafts and their beds, has opened up a very wide field of application, hitherto impossible of development. There are many technical difficulties in connection with bone work which could never be overcome except for the assistance of the motor saw and its various adjustable attachments.

In the repair of deformity and the result of traumatism of the skeleton, the advantage of the use of its own material and of the avoidance of the former seemingly necessary foreign substances has been clearly demonstrated. Metal introduced into the tissues is in most respects the direct antithesis of the bone graft. It favors infection, absorption, and disintegration of tissue.

The bone graft, being living tissue, has certain germ-resisting properties. It immediately becomes adherent and fixed to the connecting tissues. It not only stimulates the bone with which it is contacted to increased osteogenesis, but it proliferates bone on its own initiative.

CHAPTER V

THE OPERATIVE TREATMENT OF FRACTURES

JAMES MORLEY HITZROT

In no other field of surgery is there a wider range of opinion than that existing with regard to the open treatment of fractures as compared to the closed or non-operative treatment. As yet no positive dictum can be given unless one accepts Lane's statement (11) that practically all cases of simple fracture should be submitted to open reduction; or, contrariwise, accepts the opinion of those opposed to this view, that only in the exceptional case should open operation be undertaken.

With the introduction of aseptic technic into surgery, and its further development, there has been a natural increase in the number of cases of fracture submitted to operation.

The Committee appointed by the Section on Surgery of the British Medical Association has given an extremely valuable report (16) on the ultimate results obtained in the treatment of simple fracture of the long bones, occurring from January, 1906, to December, 1910. The report defines operative treatment as including any operation in which the fracture is exposed to replace the fragments, and divides the cases into three operative classes, viz.:

A. Those in which operation is decided upon at once and performed as soon as practicable.

B. Those in which operation is performed on account of failure to obtain and maintain accurate apposition by external mechanical appliances.

C. Those in which the operation is performed for faulty union, deficient union, or non-union.

The Committee considers classes B and C to consist of cases in which, in the judgment of the attending surgeon, non-operative treatment has failed; and in these cases the opinion of the surgeon in charge should be accepted as to the unsatisfactory nature of the primary non-operative treatment.

Class A furnishes a field for the comparison of the results in the non-operative as compared to the operative treatment of the cases which fall into this class.

The main conclusions from this admirable report are as follows:

1. It is possible by either non-operative or operative treatment to obtain a

high percentage of good results in children. The results of non-operative treatment in children, with the exception of both bones of the forearm, are unlikely to be improved upon by any other method. Operative results expressed in percentages are approximately the same as the non-operative; 1,017 non-operative cases, 90.5 per cent. good functional results; 64 operative cases, 93.6 per cent. good functional results.

2. In comparison with the results in children, the non-operative results in those past 15 are not satisfactory, and from the analysis of the age groups, it is clear that there is a progressive depreciation in the functional result, as the age advances, in those cases submitted to non-operative treatment, i. e. the older the patient, the worse the result.

3. Although the functional result may be good with an indifferent anatomic one, the most certain way to obtain a good functional result is to secure a good anatomic one. Of the operative methods, those which secure perfect reposition and absolute fixation of the fragments yield better results than methods which fall short of this; and imperfect fixation of the fragments *by wire* or other suture has been found unsatisfactory in fractures of the long bones (the olecranon excepted).

4. In order to secure the most satisfactory results from operative treatment, it should be resorted to as soon as practicable. Operative treatment should not be regarded as a method to be employed when non-operative measures have failed, as the results of secondary operations compare very unfavorably with those of immediate operations.

5. Operative treatment of fractures requires *special* skill and experience.

6. A considerable portion of the failures are due to infection.

7. The mortality due to operative treatment is so small that it cannot be urged as a sufficient reason against this method of treatment.

Darrach (3) puts the proportion of cases suitable for operation at 5 per cent., based upon the number of operations at the Roosevelt Hospital.

Armamentarium.—The instruments necessary for an operation are, for general purposes, those depicted below. (In special cases certain other instruments may be of service, and these will be indicated, where they are applicable, in the text.)

Lambotte clamps, 2 of each size.

Bone plates—Lane. Sherman vanadium steel.

Screws—wood screws threaded to head, self-tapping, vanadium steel, Sherman type, 3 sizes, 1/8, 1/2, 5/8 inch.

Screw holder.

Screw-driver.

Drill.

Brace and bit with drill points.

Periosteal elevators.

Rongeur forceps.

Lion jaw forceps (long handle).

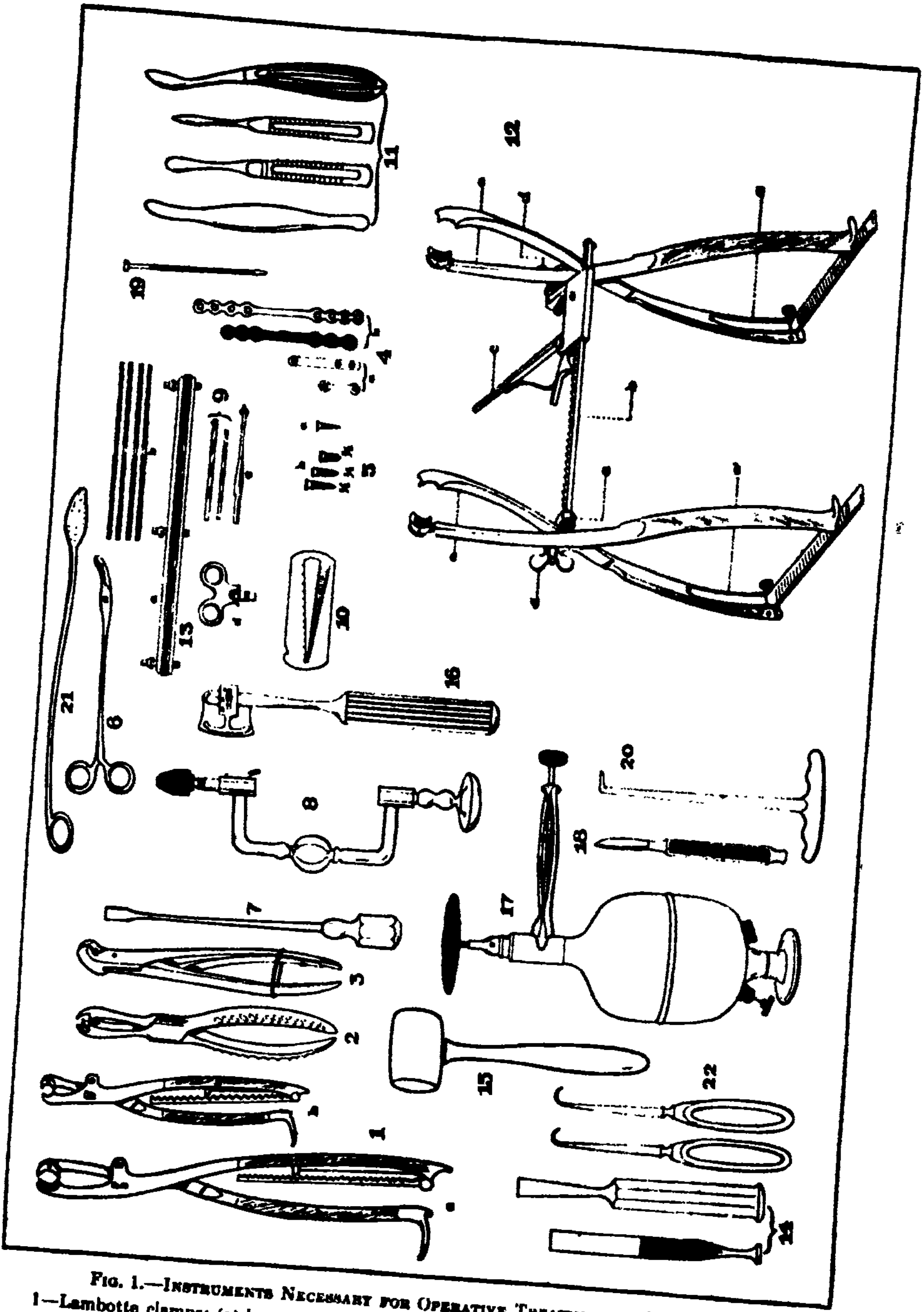

FIG. 1.—INSTRUMENTS NECESSARY FOR OPERATIVE TREATMENT OF FRACTURES.

1—Lambotte clamps: (a) large size; (b) small size; 2—lion jaw forceps (long handle); 3—rongeur forceps; 4—bone plates: (a) Lane, (b) Sherman vanadium steel; 5—screws: (a) wood screws threaded to the head, (b) self-tapping vanadium steel, Sherman type: three sizes, ⅜, ½, ⅝ inch; 6—screw-holder; 7—screw-driver; 8—brace and bit; 9—drills; 10—standard screw gauge; 11—periosteal elevator; 12—Hitzrot bone jack: (a) Lambotte clamp, (b) ratchet bar of jack, (c) lever of jack, (d) thumb screw, which fastens jack to Lambotte clamp, (e) movable bar of jack to allow for movements of the clamp to which it is attached backward and forward; 13—Freeman external bone plate: (a) bar of plate, (b) screws, (c) drill, (d) key to fasten bar to screws; 14—osteotome; 15—mallet; 16—hand saw; 17—Kenyon electric motor saw; 18—strong-bladed bone knife; 19—Lambotte screws; 20—McBurney hook; 21—Lane bone spatula; 22—bone hooks.

Freeman external plate.
Bone jack.
Screws, Lambotte type.
For bone grafting in non-union:
Osteotome.
Mallet.
Chisel.
Hand saw.
Electric saw, Kenyon model.
Strong-bladed knife.
Knives.
Clamps, etc., common to ordinary operations.
Needles.

Indication for Operative Treatment.—In general, open operation is practically always indicated in the following types of recent simple fracture:

Fracture of the patella, with separation of the fragments.

Fracture of the olecranon with separation of the fragments.

Fracture of the head of the radius with displacement of the fragments, or where the fracture line involves the radio-ulnar joint.

Fractures of the shaft of a long bone in which the soft parts become interposed between the fractured ends of the bone.

Fractures of the carpal and tarsal bones, with wide separation of the fragments or displacement of the fragments (carpal scaphoid and the astragalus).

Fracture-dislocation, viz., fracture of the surgical neck of the humerus with dislocation of the head.

Fractures of the tuberosities and condyles of the various bones with rotation of the fractured process—for example, fracture of the external condyle of the humerus, with rotation of the condyle, so that the fractured surface points outward or away from the line of fracture in the shaft.

Furthermore, operation is indicated when there is hemorrhage due to the injury of a large vessel, when there are signs of compression of a nerve, when the sharp point of a fragment is caught in the skin, and when infection has occurred in the region of the fracture.

In a second group of cases the indications for operation are variable. In this group is found a wide variety of lesions, many of which can be properly reduced by classical methods without operation. Should such reduction be unsatisfactory, open operation is indicated to correct the deformity (Class B of the report of the British Surgical Society). Necessarily the selective process for submitting the lesions in this group to open operation will vary with the experience and equipment of the surgeon, but none of the fractures belonging to this group should be submitted to an operation until a thorough examination under an anesthetic, a proper attempt at reduction and an X-ray picture of the result of that reduction have furnished the data essential to a proper judgment as to the necessity for an open operation.

Care, experience and a proper estimate of mechanical forces existent in the fractured area will give a large proportion of successful reductions by non-operative methods. In the hands of the inexperienced, success is not to be expected. In either case, a careful control of the reduction by the method above mentioned will give a basis for selecting for operation such cases as show a reduction which is not sufficient to meet the indications in the given case, or such cases in which reduction is obviously impossible.

Here, likewise, one must emphasize the fact that the recognition of the necessity for an open operation should occur within the first 2 weeks after the injury. Failure to reduce any type of fracture, even the simplest, may occur to the most experienced surgeon, but the fact that the existing reduction is a failure should not escape anyone if proper control by the X-ray, as mentioned above, be used.

Practically every type of fracture in this group may need an operation, some types with greater frequency than others. Those fractures which most frequently require operation are fractures of the long bones, especially the femur; fractures involving the joints, i. e. intra-articular fracture of the lower end of the humerus and femur; fracture of the forearm; and, in fact, any fracture which promises a poor result by virtue of an imperfect reduction.

Operation in old fractures is indicated for deformity, for non-union, for the mobilization of joints, etc., but the indications for an operative procedure in this type should not be considered with the operations for fresh fractures, nor should the result or any complication of such operation be included with the results obtained by operation in recent fractures.

Cotton (2) states that he:

1. Operates as a routine in:
    - (a) Compound fractures.
    - (b) Fractures complicated with vessel lesions.
    - (c) Fractures complicated with nerve lesions.
    - (d) Patellar fractures.
    - (e) Olecranon fractures.
    - (f) Fracture luxations.
2. Usually operates after a trial of milder methods in:
    - (a) Carpal injury.
    - (b) Fracture of the femoral shaft.
3. Often operates in:
    - (a) Fracture of humorus.
    - (b) Fracture of leg.
4. Operates on occasion in all fractures in fit patients that promise a bad result as they lie.

Contra-indications to Operative Treatment.—The contra-indications to operation upon fracture are those applicable to operations in general (see Vol. I, Chap. V).

Certain special contra-indications to operation upon a broken limb are found in infected abrasions of the skin or infected wounds of the limb near the fracture, dermatitis, and thrombophlebitis, especially in the lower leg; and it is my belief that great care should be used in the selection for operation of cases with actively suppurating wounds in any region of the body, because of the danger of embolic infections at the site of the operative trauma following the depression coincident to that operation.

The most striking contra-indications to an open operation upon a broken bone are inexperience on the part of the surgeon, unsuitable surroundings and insufficient equipment.

Furthermore, the operator should have a thorough knowledge of the anatomy of the region to be operated upon, and should understand the physical functions, i. e. the physics of the muscles, ligaments, etc., involved in the injury. Such knowledge may prevent some of the glaring faults already existent in the treatment of broken bones.

THE OPERATION

Time for Operative Intervention.—The most advantageous time for the operation lies between the fifth and the fourteenth days. Operations on small bones should come between the fifth and tenth day; on the larger bones between the seventh and fourteenth day.

Lambotte (10) varies the time of operation with the extremity involved: Upper extremity sixth to tenth day; lower extremity tenth to fifteenth day.

By this time the exudate in the region of the fracture has been absorbed, reaction in the tissues about the injured area has set in, and the fibrin framework has become deposited over the ends of the fragments. By this time it has also been fully demonstrated whether the other methods of reduction have accomplished the desired result (see Indications for Operative Treatment).

Before resorting to operation, a good X-ray picture in two planes is an essential. It is perhaps unnecessary to state that the surgeon should interpret the picture himself, that the negative should be in the operating room and visible for examination throughout the operation, and the conditions found at operation should be checked up with the detail given by the X-ray.

Immediate operative intervention, i. e. within the first 24 hours, is inadvisable for the following reasons:

1. The patient usually is in shock as a result of the accident.

2. There is an increased danger of such complications as pneumonia, delirium tremens, etc.

3. Other lesions of more importance may be overlooked.

4. Locally the tissues injured are infiltrated by blood and are more liable to infection. The skin is edematous, infiltrated, and excoriated, and surgical cleanliness is difficult to obtain.

5. Sufficient time has not ensued to determine the outcome of conservative measures.

6. There is no X-ray except in unusual cases.

The statement that there is a greater ease of reduction at this time by operative measures is largely theoretical. Certainly it can be no easier than the cases done during the time of election above specified.

Preparation of Patient for Operation.—The general preparation is that pursued for any major operative procedure (see Vol. I, Chap. IV).

The local preparation of the part to be operated upon is as follows (Author's method):

On the day preceding the operation, the part should be thoroughly shaved and washed with green soap and warm water. Then take equal parts of bleaching powder and pulverized washing soda and mix with sufficient warm water to make a thick cream, and rub this cream over the part for about 5 minutes. Wash off the cream with sterile water, then with 70 per cent. alcohol, and cover with sterile dressing while still wet with the alcohol.

On the operating table after the patient is anesthetized, this dressing is removed, the skin wiped with a mixture of equal parts of alcohol and ether, and then thoroughly covered by a solution of 5 per cent. thymol in 95 per cent. alcohol. Care should be taken to apply the alcohol thymol solution freely, and sufficient time should be given for the alcohol to evaporate.

The patient should then be appropriately draped with sterile sheets, etc. Following this the line of the immediate incision should again be wiped with the alcohol thymol solution.

Technic of Operation.[1] After the skin is incised and the deeper tissues exposed, folded sterile towels should be clamped along the skin edge to completely isolate it from any contact with instruments, etc., which enter the wound.

The fascia and muscles overlying the bone must be opened by sharp dissection and the region of the fracture *freely* exposed. Nothing is to be gained by small or even medium-sized incisions. The ends of the fragments in the long bones should be freed sufficiently, a Lambotte clamp placed upon each fragment, and by traction in opposite directions upon the handles of these clamps, the bone should be manipulated into apposition and so adjusted that the fractured ends fit perfectly. Loose fragments should be replaced in their appropriate situation or removed, as the situation demands. When the ends have been correctly apposed, a clamp—Lambotte—should be clamped across the line of fracture to hold the broken ends in position.

FIXATION OF THE REDUCED FRACTURE IN THE SHAFT OF A LONG BONE.—While fixation of the reduced fracture may be accomplished by a large number of methods, in my own experience a plate of the type described by Lane or Lambotte has been the most satisfactory. The plate should be sufficiently long, too long rather than too short, and should contain sufficient screw holes to make the strain upon the individual screw comparatively slight. The distance between the screw holes nearest to the line of fracture should be such as to avoid the entrance of the screw into the line of fracture.

A suitable plate having been chosen, the jaws of the clamp across the line of fracture are temporarily released, the plate inserted and so adjusted that its center is opposite the line of fracture with its long axis parallel to the long axis of the bone, and the clamp again locked so that the plate is firmly held against the bone.

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[1] For instruments described in text see Armamentarium.

Drill holes slightly smaller than the screws to be used should then be made in the bone through the screw holes in the plate, and the screws farthest from the line of fracture driven home. In succession, the same process is repeated, the screws proximal to the fracture line being the last to be driven into place. When these are set, the clamps are removed, the tissues dried with pads on holders, any bleeding points ligated and the tissues closed in layers—the skin loosely sutured with silkworm gut.

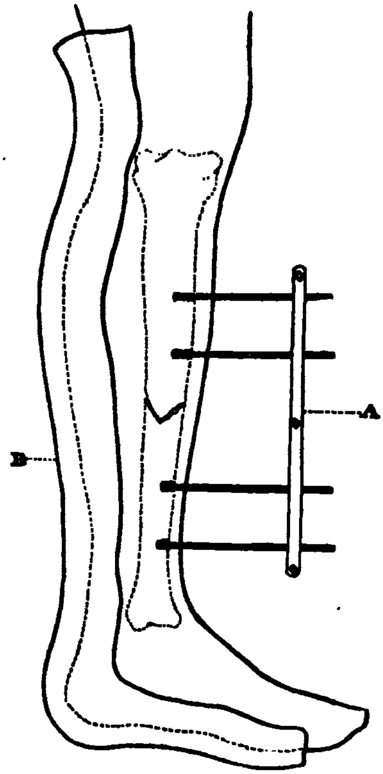

FIG. 2.—FIXATION BY FREEMAN EXTERNAL BONE PLATE IN COMPOUND FRACTURE OF TIBIA AND FIBULA. Notice the long screws in the tibia fixed by the bar A outside the skin. Dressings are placed about the wound and a moulded plaster splint B moulded along the leg as shown in the drawing. Sterile rolls are then wound about the leg and the whole dressing fixed by muslin roller bandages. Redressing may then be done without disturbing the posterior splint.

DRAINAGE.—While drainage is not necessary in the superficial bones, it is my own practice to place half of a split rubber tube at each angle of the wound in cases in which the bone is deeply situated and covered by thick muscles. These drains should be inserted before any of the tissues are closed, and not poked through an aperture in the skin when the operation is completed.

The purpose of this drainage is to allow the fluid contents of the exudate to escape and to allow for a more rapid deposit of the fibrin rather than as a preventive to infection. In superficial bones, loose suturing of the skin permits a ready outlet for the serous exudate, hence drainage by any foreign material is superfluous.

These drains may be left in place until the first dressing, the time of which must be governed by the amount of the exudate, the odor of the dressing, the temperature of the patient, etc. Usually the first dressing may be postponed to the seventh or eighth day postoperative, at which time the stitches and the drain may be removed and a dressing reapplied. No attempt to replace the drains along the drainage tract should be made. The tract will remain open sufficiently long and heal by scab formation without any further interference.

OTHER METHODS OF FIXATION OF FRAGMENTS.—EXTERNAL BONE CLAMP.—Introduced by Parkhill (12), this method has, as its most ardent advocates, Freeman (7) and Lambotte (10). The exposure of the line of fracture is made as above and the fracture reduced. The long screws are driven into drill holes in the bone above the line of fracture so that they run parallel to the long axis of the bone. The projecting ends of these screws are then fixed in the external clamp outside the skin, and the fractured ends thus held firmly in apposition.

The external clamp of Lambotte is so constructed that adjustment of the screws may be made after they are clamped to the outer bar of the external clamp, and, while it is more complicated, allows for more adjustment than that of Freeman. After the fracture is solid, the screws are removed and no foreign material is left in contact with the bone.

The clamp is especially efficacious in the treatment of compound fracture in that the screws may be placed at a distance from the line of fracture and no foreign material is placed in the wound across the line of fracture.

Fixation by Absorbable or Non-absorbable Ligature Material.—Except in widely isolated instances, this form of fixation of the fragments is of little value, despite the constant repetition of its value by the publication of reduction and wiring operations. It is not infrequent to see "the result after wiring" illustrations, with the wire broken, but the fragments in fair position, or with the wire too loose to be of service, yet with the fragments in position, all of which means that the fragments would have remained reduced without the assistance of the wire.

The varieties of wire recommended are numerous: silver, copper, phosphor bronze, galvanized iron wire and twisted steel cable. To this non-absorbable list one might add silk, linen, silkworm-gut, etc.

Personally, I can see no use for any of these types of non-absorbable ligature material, not because of their non-disappearance by the action of tissue absorption, but because they offer so little in the way of proper fixation, certainly no more than is offered by stout catgut or kangaroo tendon in the cases to which this type of fixation is suitable.

Hence I prefer to use kangaroo tendon, chromicized or plain, or catgut in the order mentioned for the fixation of fracture of the patella, olecranon, long oblique fractures in small bones, some types of oblique fractures in large bones, and in the fixation of separated apophyses.

Fixation by Nails and Screws.—Tubercles, apophyses, tuberosities, trochanters, etc., may be nailed or screwed to bone from which they have been fractured. For this purpose a wood screw threaded to the head is preferable to any type of nail. Screws of ivory or bone have a theoretical value in that they are absorbable after a long time. Practically they are foreign bodies during the same period that the metal screw acts as one and any type may have to be removed.

Fixation by Staples—Schede or Lambotte Agrafes.—This type of fixation may be used to adjust a fragment to the main portion of the bone either above or in conjunction with some other type of fixation.

INTRAMEDULLARY SPLINTS.—The advantages urged for this method are (Graves, 8): 1. It can be easily and quickly performed. 2. Requires a smaller incision and less exposure (injury) of the soft parts. 3. Involves a minimum injury to the periosteum. 4. Adjusts the broken bone in the correct position. 5. Allows for slight movements between the fragments, is beneficial for rapid union. 6. Makes the use of external splints unnecessary.

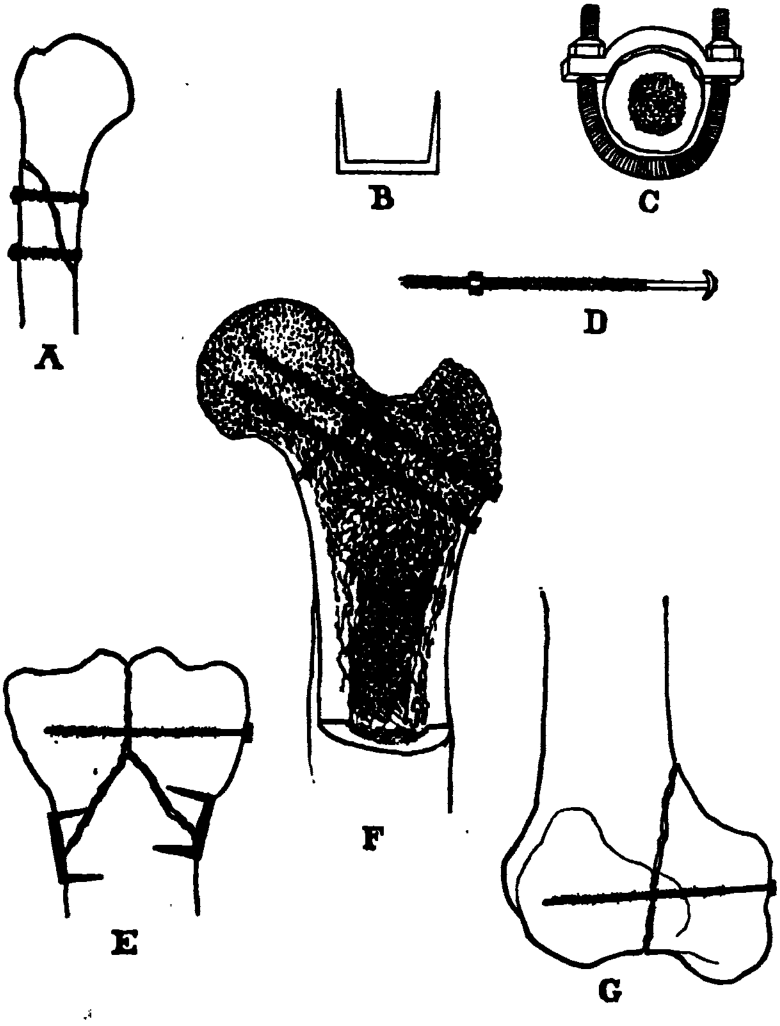

FIG. 3.—METHODS OF FIXATION. A—Fracture of humerus. Fixation by bolt and nut; B—bone staple (Schede type); C—metal bar screw bolt and nuts (after Lambotte); D—Lambotte screw bolt and nut; E—fixation of Y fractures of upper end of tibia by screw and staples; F—fixation of fracture of neck of femur by screws; G—fixation of condyle by screw.

After the operation this renders possible the use of massage passive movements as soon as the wound is healed. Phillips (13) suggests an autogenous intramedullary bone splint as a routine fixation for fractures, and gives his armamentarium.

The materials suggested for this purpose are magnesium tubes, ivory pegs, bone pegs, freshly cooked (boiled) bones, and bone grafts removed from the individual. In one case, Hartley (9) used the freshly boiled tibia of a chicken for this purpose in fracture of the femur.

In recent fractures this method, despite the contentions of its sponsors, has little to commend it because of its insufficient support at the line of fracture. The necessary injury to the medullary cavity far outweighs any theoretical advantage to be gained from the smaller skin incision.

It has, however, a distinct field in the treatment of metacarpal and phalangeal fractures, in which the deformity may tend to marked functional disturbance if uncorrected, and in certain fractures of the radius. For this latter purpose I prefer the use of an autogenous graft removed from the tibia and inserted into the medullary cavity as a dowel pin. (For further use of this method see Treatment of Ununited Fractures.)

Dangers of Operation upon Fractures. The constitutional factors are to be found under the dangers of operations in general, and do not differ from those dangers in the field of surgery.

Locally the danger in the open operation upon a broken bone lies chiefly in the danger of infection. Despite the enthusiasm of the advocates of the open treatment, the danger of infection is a real one and is not to be despised. Infection may occur (a) by the direct introduction of micro-organisms into the wound; or (b) by the deposition of bacteria from the blood stream into the locus minoris resistentiæ formed by the operation. In the lowering of the general body resistance by the operation, when a general anesthetic has been used, a further cause for infection by the blood may arise.

(A) DIRECT INFECTION.—Direct infection should and can be prevented by the adherence to a rigid aseptic technic. An indifferent technic may cause no trouble in the abdomen, whereas the same technic in bone would be fatal. Instruments, etc., should come freshly boiled to the operation and only cool enough to permit handling. Skin contact with anything which enters the wound should be rigidly avoided. Rubber gloves are synonymous with a successful outcome. No fingers should enter the wound with the exception of the operator's, and his only when absolutely required. Ligature and suture material, plates, screws, etc., should be kept from contact with air, etc., except during the period of their immediate use.

(B) INDIRECT INFECTION.—Indirect infection is more difficult to guard against and is a factor of no mean importance. Any infected abrasion on the body, tonsillitis, gastro-intestinal disorders, etc., may have tremendous potential possibilities for evil.

The only fatal case in my own experience was due to a colon bacillus infection which there is every reason to believe resulted from an intercurrent colitis, the colitis being the source of the blood invasion by the colon bacillus and the deposition of this organism about the fractured area. This type of infection tends to appear later than that due to the direct infection of the wound, and in the fatal case mentioned appeared on the twenty-fourth day after the operation.

Causes of Failure.—The operation may fail by reason of:

1. Inability to bring about reduction—a very rare cause.
2. Infection, with its consequent osteomyelitis, cellulitis, etc.
3. Failure to bring and keep the bone ends in contact.
4. If plates are used. The use of a plate which is too short or one in which the screws enter the fracture line. An improperly placed plate will become loose and cause sufficient delay in union to be considered a failure.
5. Failure of union, etc., due to intercurrent conditions (syphilis, malaria, nephritis, etc.).

Complications.—The complications are:

1. Those due to the operation, namely, infection and fat embolism.
2. Those due to delay in union or non-union of the bones.
3. Intercurrent conditions: pneumonia, delirium tremens, etc.
4. Those due to the retention of apparatus—gangrene, Volkman's ischemic paralysis, ulceration over bony points due to pressure.

RETENTION OF THE FRACTURED AREA AFTER OPEN OPERATION

Some form of external splint is essential after the open operation, which has as its excuse the more definite and correct anatomical replacement of the broken bones, and in no wise should give rise to the idea that open operation can or should dispense with an external apparatus.

Whatever the form of retentive contrivance, it should be stable, easily removed and replaced, and readily procurable.

For retention, I believe and have found from experience that the moulded plaster splints of Stimson (19) comply completely with the conditions above enumerated. All that is needed is the ordinary roller plaster bandage and ingenuity enough to make a splint suitable to the region to which it is to be applied. (Further comment upon this type of fixation will be found under the various regions.)

Circular plaster need only be mentioned to be condemned. It has no good qualities and many bad ones, especially the difficulty of removal and renewal.

Mechanical splints of steel, etc., are too expensive and too difficult to obtain, although they may in many cases fill all the above requirements (see Femur, page 253).

Wooden splints, plastic splints of felt, papier mâché, celluloid, etc., have in my experience no field of usefulness when plaster-of-Paris and a bandage are accessible.

AFTER-TREATMENT

Massage.—Massage should be begun as soon as the wound of the operation has healed or, empirically, at the beginning of the third week after the operation, and to be effective it must be more than the rubbing of an untrained attendant. It should consist in proper manipulation by a trained masseur.

Baking by the Hot Air Method (Bier or Sprague).—Baking by the hot-air method is especially valuable for fractures about the joints and for the joints which have been immobilized by the retention apparatus. This essential feature of the after-treatment should be begun simultaneously with the massage, and in my own experience has been more satisfactory when it immediately precedes the massage.

The part should be exposed to the hot air at a temperature of 160° to 200° F. for $\frac{1}{2}$ hour, and then allowed to remain in the hot air chamber until the temperature of that chamber has fallen to normal.

Hydrotherapy. Hyperemia may be induced by hot applications, i. e. by hot towels wrung out and placed upon the part. While of considerable benefit, it is not as efficient as the superheated dry air and should only be used when the other method cannot be used. In fractures about the hip joint, the hot *sitz bath* is readily applicable and is very satisfactory.

External Applications. The external application of various liniments has little or no field of usefulness, except the psychical effect upon the patient. When one cannot escape the use of an external application, a combination of methyl salicylate and camphorated oil in equal proportions serves all practical purposes without any danger to the skin, unless too vigorously rubbed during its application.

COMPOUND FRACTURES (OPEN FRACTURES)

CLASSIFICATION

Compound fractures fall into 3 groups:

A. Fractures Produced by Indirect Violence, in Which the Penetration of the Skin Occurs from Within Outward.—With the practical treatment of the modern era, this type may be considered under the same heading with simple fractures, only differing from them in the precaution necessary for cleansing and keeping clean the skin wound. The indications for operation and its details are so similar to those described for simple fractures that further detail seems superfluous.

B. Fractures Due to Direct Violence.—In this form, the lesions vary from a simple contused or lacerated wound in the soft parts which leads to an ordinary line of fracture in the bone, to extensive crushing lesions which devitalize the whole area injured and destroy the circulation in the part beyond the injury. Intermediate forms of many types exist. The essential feature of this type of injury is the lesion of the soft parts and the rôle of the bone is of secondary importance except that wounds of this type, which involve the bone, are much more liable to infection than are wounds of a similar character which only involve the soft parts.

The first step before proceeding to an operation is the determination of the presence or absence of circulation in the part distal to the injury. In doing this, great care must be used to differentiate between actual loss of circulation due to destruction of the vessels at the site of the injury and obstruction to the circulation by compression of the vessels by the exudate or a bone fragment. It will be obvious that certain cases require amputation (see Vol. II, Chap. VI for details and methods of amputating). When doubt exists it is advisable to thoroughly clean the wound (the details of wound preparation will be enumerated below), remove all foreign material, loose bone fragments, etc., correct gross bone displacement, cut out frayed and lacerated tissue which seems unlikely to survive and provide easy and efficient drainage by long incision through the upper margin of the lacerated tissue into the proximal normal tissue. The bones should be manipulated into apposition and the wound left wide open without the introduction of any foreign material, dressed with saline solution or 60 per cent. alcohol and placed in that form of retention apparatus which will permit of ready access to the wound without undue movement of the bone fragments in the injured area.

C. Fractures in Which the Injury Opens a Joint or in Which the Line of Fracture Enters a Joint.—The danger in this type is twofold: First, infection; and second, interference with function at the joint, which may result in complete ankylosis.

This type represents an exception to the rule in that, unless there are absolute contra-indications to the contrary—shock, collapse, etc.—operation should be proceeded with at once.

Under a rigid preparation with iodin, the site of the fracture should be thoroughly exposed, the wound freely flushed with saline solution and the displacement corrected. The joint, if opened by the wound, should likewise be washed out with salt solution, provision being made for drainage from its lowest level by a rubber gutter (rubber tube cut in half in its long axis) inserted so that it extends down to the joint tear of incision, but does *not* enter the joint proper.

For the maintenance of the corrected deformity, one must depend first upon an external support, or when this seems likely to be unsatisfactory, upon some type of absorbable ligature material for which purpose I prefer strong plain catgut double, so applied in the given case as to hold the bones approximated long enough to allow the application of an external dressing which must be the main support in any event.

Any type of metal support or the introduction of any foreign material into the medullary cavity is, in my opinion, dangerous, and hence contra-indicated, unless the reduction cannot be maintained by any other method.

While no definite plan of procedure can be outlined to fit this type, the above is probably the best plan of procedure for most cases—the exceptions ranging from cases in which a small spicule alone is compounded, which may receive the treatment allotted to group A, to severe crushing injuries in which the removal of the bone and wide open dressing offer the best prognosis for saving the limb.

PREPARATION OF THE WOUND IN COMPOUND FRACTURE

First Aid.—Usually the treatment first given to a compound fracture determines its outcome. Meddlesome interference under improper surroundings means infection almost invariably. Unless rapid uncontrollable hemorrhage exists, there is no indication for immediate treatment at the site of the injury. All compound fractures should have the clothing cut away from the injured area, the skin, region of the bone and any projecting bone covered with tincture of iodin, enveloped in a copious dry dressing (or 95 per cent. alcohol dressing) and splinted, and the patient should be transported to a place suitable for further treatment. When the patient has been placed under suitable surroundings, an anesthetic (gas, oxygen or ether) should be given, and the skin should be wiped with ether, benzin, turpentine and alcohol, again painted with iodin, the end of the bone cleaned, if necessary, by saline irrigation, and the bone end replaced in contact with the other fragment by manipulation entirely from without. No fingers, probes, etc., should be poked into the wound. In deep-seated bones and in cases in which complete reduction is not obtained by this means, the fracture should be freely exposed by open operation.

If reduction can be maintained without any further support at the line of fracture, none will be needed. In certain types plain catgut will maintain apposition sufficient to allow for the application of the external fixation. When this is not likely to be sufficient, the external clamp before described becomes useful.

After the reduction and necessary fixation, the wound should be loosely sutured and closed without drainage. Care should be taken to avoid strangulation of the tissues by too tight suturing and great care should be taken not to cause constriction of the limb by too tight dressing.

In the compound fractures by direct violence the wound should be opened freely, all foreign material removed by saline irrigation, the bone fragments approximated and fixed as above. The wound should be left wide open, any dependent pockets drained by split rubber tubes placed in appropriate counter openings and the wound dressed with saline solution. In cases in which much foreign material has been found or in which there is a large amount of muscle laceration, from 5 to 15 c. c. of a solution composed of iodin 1, potassium iodid 2, guaiacol 5, glycerin to 100, may be poured into the wound to increase the tissue reaction and at the same time to inhibit the infection of the devitalized tissues. The increased exudative reaction thus produced will also act as an auto-irrigation and wash out from the wound any movable particles of foreign material too small to be removed otherwise.

DELAYED UNION, FIBROUS UNION, NON-UNION, PSEUDO-ARTHROSIS

Delayed Union.—When the ends of the bone are in correct apposition, delay in union should not be treated by active surgical interference until it has been proven by X-ray negatives that bone will not bridge the fracture gap. Systemic cachectic diseases should receive their proper treatment. Locally, massage, passive hyperemia, "percussion" hyperemia may be resorted to, with almost invariable success, except in those cases in which long-standing infection has destroyed or so altered the bone that the condition becomes a failure of union.

Fibrous Union.—Fibrous union is a common result in such bones as the olecranon and the patella and is rare in the long bones. Its treatment may be left to the discussion of non-union.

Non-union and Pseudo-arthrosis.—Non-union and pseudo-arthrosis include a varying group of conditions produced by infection, the interposition of soft parts, improper reductions, improper fixation by metal sutures or fixation appliances, the interposition of bone fragments, and in isolated conditions due to nutritional disturbances in the bone fragments (for example, fracture through the neck of the femur).

Obviously improper reductions may be corrected by proper reduction. The interposition of soft parts should be recognized early, and the interposed soft parts removed from between the bone ends and the bones brought into apposition; interposed bone fragments should be recognized and removed from between the bone ends and finally no metal or other support should be used which does not keep the broken ends in intimate contact; therefore, the treatment consists in recognizing the gap between the bones, the inefficiency of the support used and consequently the removal of the improperly placed retention appliances.

When actual non-union exists or a pseudo-arthrosis has occurred due to the formation of a false joint by serous degeneration of the interposed fibrous tissue, the bone ends should be thoroughly freed, all scar tissue cut away from the ends and sufficient bone cut away to expose the medullary canal (the endosteum). The periosteum should then be reflected from the shaft by a longitudinal incision far enough to reach the normal bone (procedure applies to both fragments). With a motor saw a groove is then cut into the bone about $3/8$ in. wide and deepened to the medulla with its slides sloping from without in. (A gouge or chisel may be used for this purpose, but is not as satisfactory.) When this bed is sufficiently prepared, a bone graft is taken from the tibia at its inner aspect or from the crest, with periosteum attached and cut wedge-shaped and approximately large enough to fit the slot spoken of above. The graft should have the medulla on its under surface. The graft is then countersunk into the

slot, medulla in contact with medulla, cortex with cortex and the periosteum fastened to the reflected periosteum and soft parts of the host bone.

To cut the graft properly a motor driven saw is essential. Personally, the Kenyon motor saw, with single circular saw blade, has proven the most satisfactory. The double saw blade (Albee), while it assures a graft and slot of equal size, does not allow the edges of the slot or the graft to be cut slantwise and does not assure the same degree of firmness in the placing of the graft as can be obtained by wedging the graft into a V-shaped slot. The graft should be cut heavy enough to act as a rigid support and pressed home into the slot in firm contact with the host bone. If it should tend to slip out, two or three loops of heavy plain catgut tied around the whole bone at each end will suffice to keep it in place.

Sutures, metal or bone pins passed through drill holes in the graft are unnecessary and weaken the graft. Albee has used bone pegs fitted to drill holes through the host bone, with a projecting end pressing against the graft to hold it in place.

Intramedullary splints of bone, ivory, magnesium, etc., have a field of usefulness when the above type cannot be applied. The dowel pin should be sufficiently large to fit firmly into the prepared medullary cavity. If too small to prevent its slipping into one end or the other, it should be fastened by an absorbable ligature passed through drill holes through the host bone and graft. The method is especially applicable in small short bones, and in fractures at the lower end of the femur.

REGIONAL SURGERY OF FRACTURES

For operative treatment of fractures of the skull, see Vol. II, Chap. VII; of the spine, Vol. III, Chap. XV; of the bones of the face, Vol. II, Chap. VIII.

FRACTURES OF BONES OF THE NECK (OTHER THAN VERTEBRA)

Fracture of the hyoid bone, of the cartilages of the larynx and of the trachea may be considered together inasmuch as the operative treatment for the whole area is dependent upon the coincident obstruction to respiration in injuries of the above bones and cartilages.

Intubation by a firm rubber tube or by one of the ordinary intubation tubes (O'Dwyer) may be sufficient in mild cases. Tracheotomy (see Vol. III, Chap. VIII) is, however, the chief method of procedure. Following the tracheotomy, the displacement of the bone or cartilage should be corrected and if necessary held in position by absorbable sutures appropriately passed to overcome the displacement.

FRACTURES OF THE SCAPULA

Fractures of the scapula as a rule require no operative intervention.

FRACTURES OF THE CLAVICLE

Recent simple fractures as a rule can be reduced sufficiently without operation. In rarer cases the deformity cannot be overcome, or a sharp end may be caught in the skin, and in these cases under local infiltration anesthesia the fracture line may be exposed by an incision parallel to the lower border of the clavicle, the 2 fragments caught by bone hooks and approximated. No retention other than the external fixation is required unless the line of fracture is oblique, when fixation by absorbable ligature or an intramedullary splint may be required to retain the reduction.

Metal splints of the Lane type should not be used in the clavicle.

Compound fractures of the clavicle should be treated by the methods enumerated under Compound Fractures in general. When reduction cannot be maintained by appropriate external retention apparatus, the Freeman external bone clamp adapted for use in the clavicle may be used.

Operation may furthermore be indicated for injury to the vessels or nerves in fractures of the clavicle.

When a projecting end of bone or a large irregular callus causes discomfort, the projecting end of the callus may be removed and the bone rounded off by a rongeur forceps.

FRACTURES OF THE HUMERUS

Fractures of the Greater Tuberosity.—When a large fragment is torn off and widely separated from the head of the bone, it may require open replacement. Through an anterior incision between the deltoid and major pectoral the fractured area is exposed, the fragment caught and replaced in contact with the shaft. It may be fastened in position by a suture passed through the bone and around the tendon of the infraspinatus, or by a suitable screw or nail, and the arm placed in extreme outward rotation to relax the pull of the external rotators.

Dislocations of the Head with Fracture.—The lesions which may require operative interference at the upper end of the humerus are:

Fracture dislocations, i. e. dislocations of the head with fracture through the anatomical neck, the epiphyseo-diaphyseal junction or the surgical neck.

Two operative procedures may be followed for these injuries, namely: Removal of the head or replacement of the head into the joint and its fixation to the shaft.

In either case the most satisfactory method of approach lies through an anterior incision between the deltoid and pectoralis major. By this route the fractured area is exposed and further steps to be undertaken can be determined.

The head may be removed or, if conditions are suitable, the anterior surface of the joint capsule may be opened, the head inserted and fastened to the shaft by suitable screw, bone peg or nail.

In elderly or debilitated individuals, removal of the head is by far the simpler and safer procedure. Frequently the head may be found in the axilla close to the anterior border of the pectoralis major, and it may be removed by an incision along the anterior axillary fold in cases which do not warrant a more extensive investigation.

When the fracture involves the surgical neck with dislocation of the head, replacement of the head may be made by use of the McBurney hook. The right-angled prong of the hook is inserted into a hole drilled in the cortex of the upper fragment, the head dragged down and replaced through the rent in the capsule and then the fractured ends approximated.

The further details resemble those for the fractures of the surgical neck, and may be considered there.

Fractures of the Surgical Neck.—Open operation is indicated in cases with marked comminution of the upper fragment; with rotation of the upper fragment which cannot be overcome by postural treatment; with axillary displacement of the upper end of the lower fragment which cannot be overcome by other methods; and in penetration of the deltoid by the upper end of the lower fragment.

The best method of approach is through an anterior incision between the pectoralis major and the deltoid, or through the anterior fibers of the deltoid muscle. After the fracture line is properly exposed, the existent conditions are treated by replacing the fractured ends in contact, where they will remain without further fixation. When the upper end is split into many fragments, these may be fastened together by screws, or the upper fragments may be removed and the external rotators and the subscapularis reattached to the shaft.

The wound is closed without drainage and the arm put up in moulded plaster splints. These moulded splints are 2 in number, a posterior splint which begins at the root of the neck and passes down the posterior aspect of the arm to the wrist, leaving that joint free. In cases requiring only moderate degrees of abduction an anterior splint is used. This begins at the angle of the opposite scapula, passes up across the neck limb of the posterior splint, capping it, and then down the anterior surface of the arm to the wrist, leaving that joint free.

In placing these splints a dressing is placed over the wound, and the posterior splint applied and bound to the arm in the region of the wound with sterile gauze rolls.

This procedure permits examination of the wound without the removal of the posterior splint, and is especially valuable when no type of internal fixation has been used, in that there need be no fear of displacement during the manipulation coincident to the dressing.

If a wider angle of abduction seems necessary, the anterior splint may be replaced by a thoracicohumeral splint, which begins at the crest of the ilium, passes up across the axilla in a wide dome-like curve and down the under surface of the arm to the elbow. With this the arm may be held in any position including that directly erect along the head.

The splints are bandaged in position with muslin bandages, care being taken to avoid circular constriction of the arm by the bandages.

The after-treatment is similar to that for fractures in this region; massage and baking (or hydrotherapy) are begun on the tenth to fourteenth day, and passive movements at the end of the third week, avoiding movements in rotation until a week later.

Fractures of the Shaft.—Operation may be indicated for long oblique or spiral fractures, for injury to or inclusion of the musculospiral nerve in the callus, and for non-union.

The method of approach varies with the situation of the fracture, but is usually made on the outer aspect of the arm and should be long enough to give free access to the line of fracture.

When the bone is exposed, the fractured surfaces are approximated and clamped together by a Lambotte clamp. The broken ends may then be held in apposition by kangaroo tendon or wires passed about the bone, by an intramedullary bone splint, or fastened by bolts, or a Lane plate.

The external retention splint is described above, and the after-treatment is that given above, with caution as to its use too early. (The writer prefers using it in the fifth week—usually 30 days.)

Fractures at Lower End.—The great variation in type of the fractures at the lower end of the humerus makes description of a fixed method of procedure impossible. In general, reduction under an anesthetic with an X-ray picture of that reduction is an essential factor in determining the necessity for operation. Imperfect reductions indicate operative intervention, with the correct replacement of the fragments.

The method of approach may be by an external incision along the external supracondylar ridge, especially for fractures of the external condyle, and for supracondylar fractures, over the internal condylar ridge for the internal epicondyle and condyle; or through the triceps muscle, splitting the fibers of that muscle to approach the fracture line, especially in T- or Y-shaped fractures which extend into the joint.

Internal fixation may be unnecessary, or one may require any of the several types suggested in general discussion on fixation. It is best to use that form of fixation which will retain the reduction most perfectly. Care should be taken to keep the fixation apparatus out of the olecranon fossa.

Old fractures at the elbow which give poor results by virtue of imperfect reduction are difficult to handle because of the large amount of new bone thrown out. In children the fragment should be liberated, the new bone completely removed from the anterior and posterior surfaces of the shaft, the olecranon fossæ cleaned out, and the arm carried forward into the hyperflexed position. Usually this will suffice to bring about a satisfactory reduction. If it does not, the lower end of the upper fragment should be cut to fit the upper edge of the lower fragment, and the bone-ends approximated and the arm then hyperflexed. As a rule, no internal fixation is required.

In adults with complicated fractures, with ankylosis, or with so much limitation in motion that the arm is useless, the most satisfactory expedient consists in an arthroplasty with the removal of the malunited fragments and the rounding off of the lower end of the humerus to resemble the articular surface. The free edge of the bone is then covered by a fatty fascial transplant, so that all raw bone is completely covered. The wound is now closed, the arm put up in flexion in a moulded internal plaster splint, with sufficient pressure against the lower arm to keep the joint surfaces apart. The resulting function of such a procedure has given a more satisfactory arm than has resulted from the attempted reposition of the fragments – a very difficult task—or from a resection of the elbow joint.

FRACTURES OF THE RADIUS AND ULNA

Fractures of the Head of the Radius. Fractures of the head of the radius require operation when the fracture line extends into the upper radio-ulnar articulation; when the fragment is separated from the remainder of the head and more or less widely displaced; and for comminuted fractures of the head.

Two procedures may be undertaken: First, the removal of the head through the neck with closure of the orbicular ligament, and, secondly, a muscle flap over the raw bone of the neck; or the removal of the fragment or fragments alone. This latter procedure is only advisable in the second type mentioned above.

Complete removal by the method mentioned gives a functionally perfect arm without any great loss of motion.

Fractures of the Neck of the Radius.— Separation of the radial epiphysis should be replaced in children.

In fractures of the head of the radius, with long lines of fracture extending into the neck, the head and neck should be removed, care being taken to preserve the attachment of the biceps.

Oblique fractures of the neck are best treated by operation with suture of the fragments by kangaroo tendon.

The steps of the operation are as follows: Incision from the supracondylar ridge, through the cubital fossa, with retraction of the brachioradialis forward, exposure of the head of the radius and its removal with a Gigli saw or bone-cutting forceps, layer closure of the wound without drainage, arm dressed in flexed position in full supination.

Fractures of the Shaft of the Radius. – Operation is indicated for fractures of the upper and lower thirds of the radius and for the middle third if reduction under an anesthetic has failed.

The operation should be done on the fifth day through an incision along the course of the radius, splitting the muscles along the intermuscular septum down to the bone, liberating the fragments and fixing by appropriate fixation—absorbable suture, intramedullary bone dowel or steel plate—as the condition demands. As a rule, the rotation of the fragments in the high type will require a steel plate to completely correct the deformity. Elsewhere the other types of fixation will suffice, except in rare instances.

Operation for Colles' Fracture.—Skinner (18) gives a method for calculating the prognosis in Colles' fracture. He formulates that the entire styloid process of the radius is distal to a line which is drawn through the tip of the ulnar styloid at right angles to the longitudinal axis of the radius. The function at the wrist joint depends upon the reduction of the lower end of the radius to bring about this alignment.

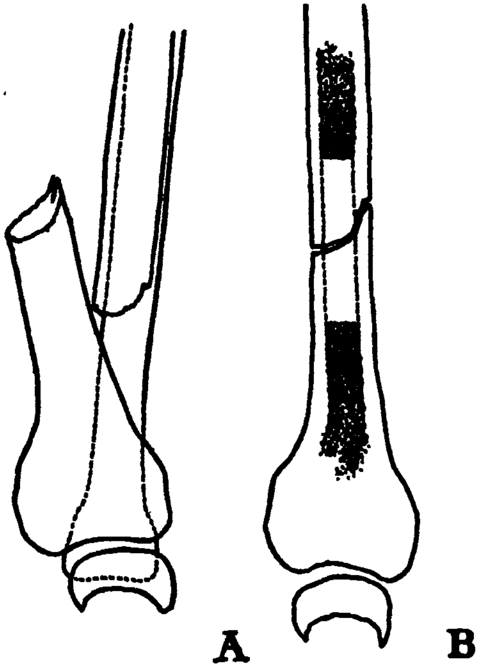

Fig. 4.—Fracture of Lower Third of Radius. Drawn from X-ray negatives, N. Y. Hospital. A shows best reduction obtainable by manipulation. B shows reduction and fixation by intramedullary dowel from the tibia.

Recent Colles' fracture needs no operation unless it is a compound one; but in old cases with uncorrected deformity, in which the joint surfaces do not conform to the above mathematical adjustment, a bad result functionally is likely and an open operation should be resorted to.

The line of fracture may be approached by a dorsal incision with the retraction of the thumb extensors toward the thumb side, or through a lateral incision with retraction of the thumb extensors ulnarward.

Through the first-named incision the fractured line is exposed and the fragments liberated with a fine osteotome and the ends freshened if need be. Accurate replacement is then brought about by raising the lower fragment and carrying the hand in hyperextension until the posterior edges of the two fragments engage. The hand is then flexed and carried into full ulnar flexion, the wound closed without drainage, and the arm put up in moulded plaster splints, leaving the fingers free. Posture will maintain the reduction and internal fixation is superfluous.

Unwise operating upon old Colles' fracture with good function, for the purpose of cosmetic improvement, should be undertaken with considerable caution, inasmuch as cosmetic improvement may be obtained at the expense of function.

Fractures of the Olecranon.—Operation is indicated when there is separation of the fragments. The time of election is the fifth day after the injury.

Through a longitudinal incision over the olecranon the fracture line is exposed, the two fragments pulled apart by bone hooks, and the joint irrigated with normal saline until all blood is removed. The periosteum is then reflected from the lower edge sufficiently to permit a drill hole being made through the ulna below the line of fracture. Through this drill hole a stout kangaroo tendon suture is passed. The inner end is then threaded on a needle and the suture passed through the triceps fascia and tendon, close to the tendinous attachment of that muscle to the bone, down to the drill hole opening on the outer side of the ulna, and through it to the inner side again. The arm is then brought into full extension and the ligature tightened and tied over the bone behind, the assistant meanwhile pressing the ligature firmly against the drill holes to prevent slipping during the process of tying the suture. The torn fascial expansion is then closed with a few fine interrupted chromic gut sutures, and the wound closed without drainage. The arm is put up in full extension with a moulded anterior plaster splint from the axillary fold to 1 in. above the styloid process of the radius.

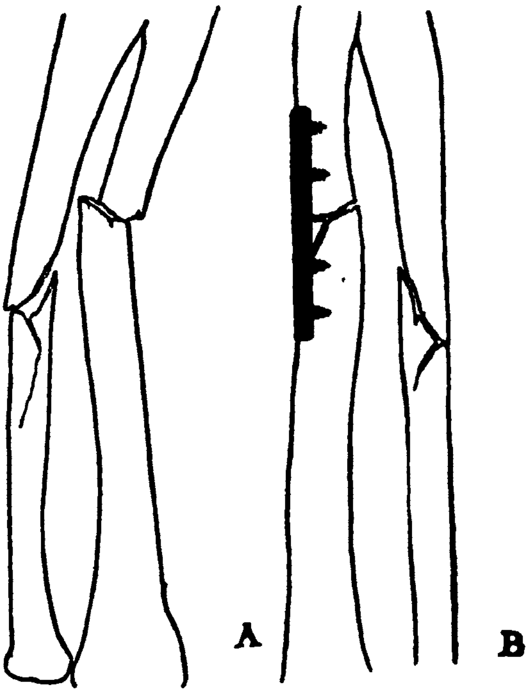

FIG. 5.—FRACTURE OF BOTH BONES OF FOREARM. Upper third—adult. Drawn from X-ray negative, N. Y. Hospital. A shows fracture with best possible reduction obtainable by manipulation. Note rotation of the radial fragments. B shows the same after fixation by steel plate and screws in the radius. Note another method of controlling a loose fragment by placing it under the plate.

The first dressing is applied in 2 weeks, at which time the stitches are removed. The arm is then baked and massaged. At the end of the fourth week—twenty-eighth to thirtieth day—passive movements in flexion are begun and the splint removed on the forty-second day, after which period movements in flexion and extension are encouraged. Full use of the arm should occur in from 10 to 12 weeks.

Fractures of the Shaft of the Ulna.—Fractures of the shaft of the ulna rarely require operation. Should the displacement require it, the subcutaneous situation of the bone renders the operation easy. Compound fractures of the ulna are best treated by operation with replacement of the fragments.

Fractures of Both Bones of the Forearm.—Fractures of both bones of the forearm require operation when the fracture is compound, when there is muscle or fascia between the ends of the radial fragments, and when reduction under an anesthetic or by traction in the suspended position does not bring the bones into proper alignment.

In children operation is rarely required except in very rare instances.

After 14, operation is much more frequently necessary, especially so in strong muscular adults. In the later years reduction is rarely complete (usually about 20 per cent.) by non-operative methods, and may be considered satisfactory in from 30 to 40 per cent. of the other cases.

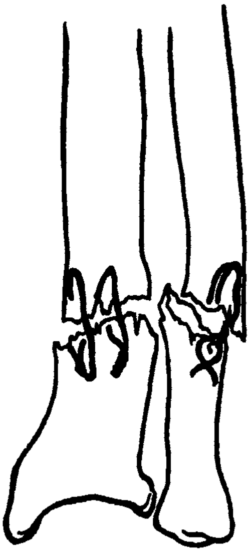

Fig. 6.—Fracture of Both Bones of Forearm. Fixation by silver wire sutures. Non-union. Note the fact that the bones are in position with the wires broken. (From X-ray negative, N. Y. Hospital.)

Many factors must govern the indications for and against open procedures in these cases, but, other things being equal, that individual whose earning capacity depends upon a strong, useful arm will obtain that arm more surely and more rapidly after an open operation than by any other means.

Both bones should be exposed by lateral incisions over each bone, exposing the radius first on the fifth to the seventh day after the injury.

The type of fixation may be variable, but in general that type which keeps the broken ends in the firmest apposition is the most successful. The choice, therefore, lies between the steel plate and the intramedullary dowel of bone—at least for the radius. In high fractures or in fractures above the middle of that bone, the plate has proven the more satisfactory. In those lower down the choice must depend upon the indications, always bearing in mind that fixation is the thing desired.

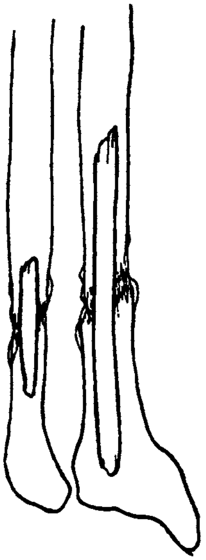

Fig. 7.—Fracture of Both Bones of Forearm. Old compound pseudo-arthrosis. Wedge-shaped bone graft from the tibia placed in slot in the bones. Sketched from X-ray negative, N. Y. Hospital, 14 weeks postoperative. Notice the length of the radial graft and the new bone between the fracture ends. (See text page 245 for details.)

The ulna in many cases will require no fixation, or may be fastened by absorbable suture, intramedullary dowel, or plate in the order mentioned.

The wounds are closed without drainage, the arm put up in the position midway between pronation and supination in a moulded splint, which passes from the mid palmar fold of the hand around the elbow, down the dorsum to the knuckles, leaving the fingers free. The arm should be suspended for 48 hours and then may be carried in a sling.

The after-treatment comprises massage and baking, especially of the wrist and elbow joints, in the fourth week. Active motion of the fingers should be encouraged from the beginning.

The healing process should be studied by the X-ray and the time of the removal of external fixation should be governed by the character of the callus. As a rule, external fixation is necessary for from 8 to 14 weeks, and complete use of the arm for strenuous labor should not be allowed for 4 months.

When non-union has occurred, as a result of improper fixation, the interposition of soft parts, infection, etc., the bone ends should be freed and all fibrous tissue cut away, the lesion treated by an autogenous bone graft from the tibia, as described on page 238 *et seq.*

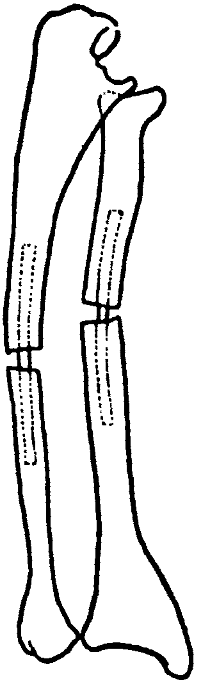

Fig. 8. Fracture of Both Bones of Forearm Old United. Intramedullary splint from 9th rib. Failure Sketched from negative, N. Y. Hospital. Absorption of the graft occurred between the bone ends and fibrous union occurred. Failure was due to improper selection of bone for grafting and insufficient removal of the sclerotic bone to allow new bone to grow down along the graft.

FRACTURES OF THE CARPUS AND METACARPUS

Fractures of the Scaphoid. The most common type of carpal injury is that of the scaphoid either as a fracture of that bone alone, or of the scaphoid with dislocation of the semilunar and fracture of the posterior lip of the lower end of the radius.

In general, the latter two varieties require operation, while operation is indicated in the former only when the proximal fragment of the fractured scaphoid is so displaced that it cannot be brought into apposition with the distal fragment. An X-ray negative is essential for the proper determination of the procedure to be undertaken.

The operation should be done on the fourth to fifth day after the injury. The intervening time should be used to prepare the hand for the operation, i. e., to render the skin clean. The incision should be made over the dorsum of the hand between the extensors of the thumb and fingers and the thumb muscles retracted outward (radialward).

Excision of the proximal fragment of the scaphoid or of that fragment with the semilunar and the fragment of the radius is the procedure of choice. It is wiser to leave the distal fragment of the scaphoid. In old injuries with a marked arthritis excision of the whole proximal layer of bones will result in greater function with less pain.

The wounds are closed without drainage and the hand put on a palmar splint in ulnar abduction, with the fingers free and motion of the fingers encouraged.

The wrist should be baked daily from the fifth day and the splint removed at the end of the second week.

Fractures of the Metacarpals and Phalanges.—Operation is rarely required for these bones except for the crushing injuries which will be discussed elsewhere.

Occasionally metacarpal fractures cannot be suitably reduced and the resulting lateral displacement with some overriding of the fragments will leave limitation in flexion of the hand. Such cases, especially in those whose occupations require perfect closure of the hand, will require open reduction.

The type of internal fixation best suited to this form of injury is the medullary dowel.

In rare cases fracture of the base of a phalanx may allow a small fragment to fall into the joint. Being a foreign body in a joint, it should be removed by operation.

FRACTURES OF THE STERNUM

Fracture of the sternum with marked displacement may be reduced by a transverse incision along the line of fracture. With the body extended, the 2 fragments may be pried into position by periosteal elevators or bone hooks so placed as to elevate the upper fragment and bring it in contact with the lower one.

FRACTURES OF THE RIBS

Fractures of the ribs do not as a rule require open operation. When a fragment of the rib penetrates the pleural cavity, lacerates the liver, spleen, or kidney, the fragment should be elevated or removed and the lesions in the lung (Vol. III, Chap. XI), liver (Vol. IV, Chap. IV), spleen (Vol. IV, Chap. VI), and kidney (Vol. IV, Chap. XII) treated by appropriate operative measures.

Rarely the callus may compress the anterior segment of the intercostal nerves with pain or even paralysis of the upper abdominal muscles. In such cases the nerves involved should be freed.

FRACTURES OF THE PELVIS

The operative treatment of this type of injury is as a rule confined to the treatment of the coincident injuries to the soft parts and viscera, i. e. to ruptures of the urethra and bladder and injuries to the pelvic organs in the female.

When a portion of the crest of the ilium is torn away by muscular violence and the displacement sufficient to warrant it, the fragment may be sutured in place by kangaroo tendon through the muscle above the fragment and through drill holes in the bone, and the fragment brought into position by this means.

FRACTURES OF THE FEMUR

Fractures of the Head and Neck.—Fractures of the head and neck of the femur do not, as a rule, require operation in the recent state, unless the neck is driven into the head fragment to such an extent that the head is displaced downward and backward and manipulation cannot bring the fractured ends into apposition, or unless the head is completely rotated in the acetabulum so that its cartilage is in contact with the fracture of the neck.

In old fractures which, by virtue of neglect or improper treatment, have resulted in deformity and disability, many operations have been devised to meet the existing condition. If the deformity consists in union in the coxa vara position, the indication is to restore the normal angle of the neck by removing a wedge-shaped piece of bone at the base of the trochanter sufficient to permit of full abduction of the leg (Whitman).

In old cases of epiphyseal fracture with deformity and disability, the joint may be opened through an anterior incision which will expose the fractured end of the neck lying above and in front of the head. By removing a thin section from the neck a chisel may be inserted and the 2 fragments brought into apposition by prying the neck into contact with the fractured surface of the head and coincident rotation of the leg (Whitman).

In both of the above the limb should be fixed in complete abduction by plaster, and weight-bearing should be prohibited for at least a year.

In old cases of fracture of the neck of the femur with non-union, with absorption of the neck and atrophy of the head, and in cases with absence of union after 2½ months, open operation is indicated (Flint, 6) in cases able to bear operation.

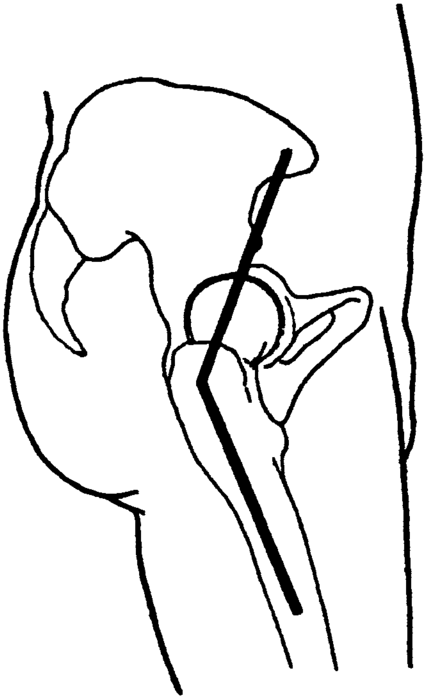

Fig. 9.—Line of Incision for Fractures Involving Upper End of Femur. (Diagrammatic after Flint.)

The incision most suitable for these cases is that recommended by Flint. The skin is incised from just behind the anterosuperior spine of the ilium down to the posterior portion of the trochanter major, and then about 5 in. down the thigh. The skin and fat of the posterior flap of the incision are dissected backward, exposing the posterior border of the tensor vaginæ femoris, which is then divided from above obliquely forward and downward and drawn forward, which exposes the hip joint covered by a fat pad. This fat pad is then excised and the anterior margin of the greater trochanter, the capsule of the joint, and the brim of the acetabulum exposed. The capsule is then opened by an incision beginning at the acetabular brim close to the fibers of the Y-ligament and follows the ligament down to the shaft close to the attachment of the capsule to the neck, when it is carried upward to form a triangular flap, which readily exposes the seat of fracture. Care should be taken not to separate that portion of the capsule attached to the head fragment in fractures at the base of the neck.

The next steps depend upon the conditions found. When possible, the ends may be freshened and fastened together by a bone peg, screw, or nail, passed through the trochanter into the head. For this purpose Preston (14) has devised a screw with a plate, which is fastened down the shaft of the bone to prevent displacement by the action of the hip and thigh muscles.

If conditions are such that the head fragment must be removed, the ligamentum teres is cut, the head removed, the cotyloid cartilage cureted away with a sharp spoon, the neck end freshened, the anterior-inferior margin of the acetabulum cut away (otherwise the projecting lip will rotate the femur outward), and the periosteum over the brim of the acetabulum, the outer side of the femur, and the inner side of the trochanter should be stripped up to allow of bone approximation. An osteotomy is then done through the base of the great trochanter. The line of the osteotomy should be slightly oblique so that the trochanter may fit in the angle between the shaft and the pelvis. There may be an annoying hemorrhage while performing this osteotomy, due to injury to an artery lying in the digital fossa.

After the shaft has been placed in the acetabulum the trochanter is fastened to the pelvis by a stout bone peg or screw (Gangolphe). The result desired is to have bony union between the shaft and the acetabulum.

Fracture of the greater and lesser trochanter rarely requires operation. The reported cases are few and function has been restored without operation.

Fractures of the Shaft.—Fractures below the trochanter (subtrochanteric) and fractures of the shaft involving the trochanters usually require operation for a satisfactory result. The lesion is usually a complicated one and is best approached through an incision similar to that described above, except that the upper limb is shorter, while the lower limb is carried further down the thigh and more anteriorly. Fixation is best obtained by a steel plate with accessory fastening, with kangaroo tendon or steel wire, of the separate fragments. The external fixation and after-treatment will be described with that of the shaft.

Fracture of the shaft of the femur should be examined under an anesthetic and reduction attempted as soon as possible after the injury, preferably within the first 24 hours. An X-ray is then taken to determine the result of such manipulation, and from this X-ray must be determined the subsequent course of treatment.

Operation is indicated in complicated fractures, especially spiral fractures with comminution; in oblique and transverse fractures which are not reduced after 1 week's traction (the traction should be placed upon suitable cases and an X-ray taken with the traction apparatus in action); in fractures in which the muscle is penetrated (absence of bony click in manipulation); in injuries to the vessels; in compound fractures; and in all cases in which satisfactory apposition of the fragments is not obtained and maintained by bloodless methods.

The operation should be undertaken on the tenth to the fourteenth day after the injury. The preparation is that previously described (see page 229), and the incision should be free enough to fully expose the line of fracture.

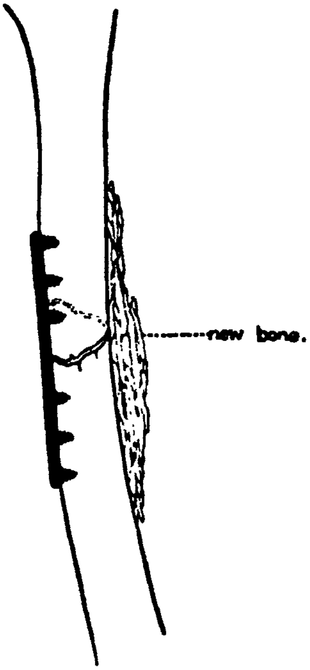

FIG. 10. — FIXATION OF A TRANSVERSE FRACTURE IN FEMUR. Robus young man of 20 years, N. Y. Hospital. Note the new bone on the concave side of the fracture bone.

The fracture is then reduced by using the Lambotte clamps and manipulation, by attaching the Hitzrot bone jack (Fig. 1), and jacking the bone apart, or by some sort of external traction such as that recommended by Lambotte, the use of the Lemon, Echols, or Hawley extension apparatus, or the traction apparatus of Martin. The bone jack above mentioned readily reduces the fracture, and by virtue of its adjustability brings the fragments into apposition and fixes them there. A steel plate (see page 229) is then screwed into place. The wound is closed with or without drainage, depending on the amount of hemorrhage (oozing) encountered, and the leg is put up in moulded splints.

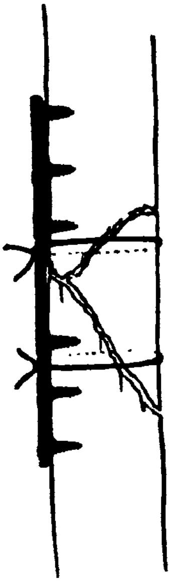

FIG. 11. FRACTURE OF FEMUR. Note the position of plate and screws to the line of fracture. The loops passed about the loose fragment are of No. 3 plain catgut and illustrate a method of controlling such fragments as cannot be held by the plate. The position of the bone is sketched from the X-ray negative and the loops are shown diagrammatically as they could not be seen on the plate. (Drawn from X-ray, N. Y. Hospital.)

These moulded splints are 3 in number. The first is a posterior splint which extends from the posterior iliac crest down the back of the leg to the expansion of the tendo Achillis into the muscle. This splint is bound into place by sterile rolls placed about the region of the operative incision. The second splint is a long lateral splint which extends from the axilla along the side of the body and leg down to the end of the posterior splint. The chest wall and flank should be well padded with cotton when placing this splint. The third splint begins in the flank on top of the second splint and passes down across the anterior and internal surface of the thigh to the knee.

When these splints are in position and moulded to conform to the limb, they are bandaged in position by muslin bandages. A long experience with these splints has proven their many advantages and the fixation obtained is absolute.

The first dressing is made on the tenth day, and the stitches and drain, if used, removed. Massage of the leg and baking of the bone and joint are begun on the eighteenth day and movements of the knee the week following, care being taken to support the line of fracture during this process.

On the twenty-eighth day a hip brace (Fig. 13) is applied and the patient allowed to get up and about on crutches. This brace is worn constantly until sufficient callus is formed to support the leg, when it may be removed at night. No weight is allowed without support until 4 months postoperative, and then only when the X-ray shows a sufficient callus to support the inevitable strain. By the time this is possible the knee joint is movable enough to permit of flexion to or beyond a right angle, and function rapidly returns with the increasing use.

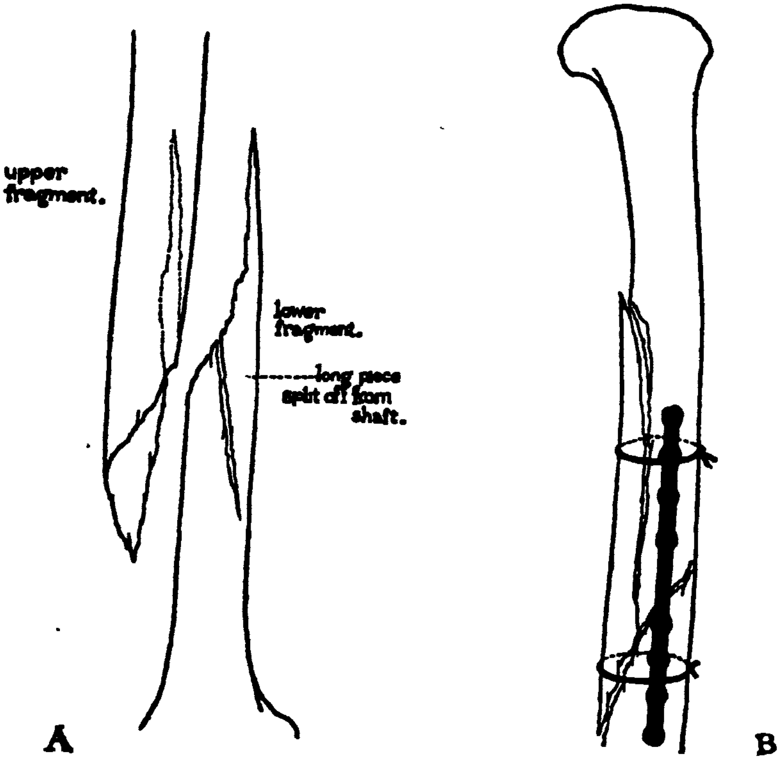

Fig. 12.—Complicated Spiral Fracture of Femur. Female, aged 24, N. Y. Hospital. A shows the best reduction obtainable by traction. The spiked end of upper fragment was caught in the muscle. B shows the fracture after open reduction. Sherman steel plate. The loops in the illustration are No. 3 plain catgut and are inserted to show the method of fixing the long piece split off from the shaft.

In compound fractures early operation is indicated in the vast majority of cases. If shock, etc., do not contra-indicate it, the operation should be done within the first 24 to 36 hours, the fragments being approximated and fixed by the Freeman or Lambotte external bone clamp (Fig. 1). This type of fixation is preferable because the screws extend outside the injured tissues and no foreign material is left in contact with the site of the fracture. The incision is loosely closed, freely drained and dressed with the alcohol and thymol solution, and a suitable external support is employed.

The plate and screws are removed at the end of the fourth week and the subsequent treatment is similar to that described for simple fracture.

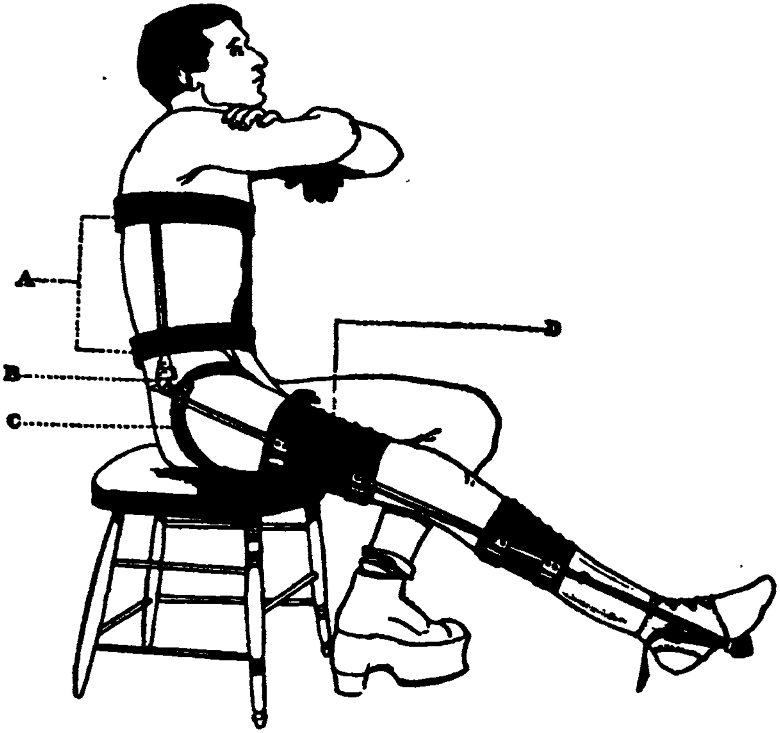

Fig. 13.—Modified Taylor Hip Brace for After-treatment of Fractures of Femur. This is placed on the operative cases four weeks after the operation, and the patient allowed to get up and walk about on crutches. A—Waist band with canvas corset laced on the side not shown in the illustration. B—Joint with automatic lock which allows the patient to sit down by moving the cap of the lock up. On standing it falls into position and fixes the joint. C—Perineal ring. This is hinged so that it may be opened. D—The upper leather re-inforcement is placed at the line of fracture over the femur. The inside bar parallels the outer bar to the perineal ring. (It is not shown in this view.)

Amputation may be indicated when the muscles of the thigh and the great vessels are so injured that the distal portion of the leg does not seem likely to survive.

Fractures of the Lower End.—EPIPHYSEAL SEPARATION.—When the displacement is such that it cannot be completely corrected by mild manipulation, operation is indicated.

Through an internal lateral incision the bone may be pried and manipulated into position, care being taken not to hyperextend the lower leg too far because of the danger to the great vessels. When approximated it will remain so without internal fixation.

SUPRACONDYLAR FRACTURES.—In the adult supracondylar fractures can rarely be reduced by other than operative means. Should reduction under an anesthetic fail, open operation should be resorted to and the broken ends approximated. If they can be held, no fixation is required. If the displacement tends to recur, fixation may be obtained by a suitable plate, staples on both sides, or an intramedullary bone splint. The type of fixation must be chosen to suit the individual case.

FRACTURES OF THE CONDYLES.—Fracture of the condyles and T and Y fractures at the lower end of the femur may be reduced and fastened by suitable screws so inserted as to avoid entering the joint or approaching too close to the articular cartilage.

FRACTURES OF THE PATELLA

Two types of this particular fracture exist. The first is produced by direct violence, and fixation by external means usually suffices, except in those cases in which a fragment is split off from the articular surface of the patella and falls into the joint; in which case, if unrecognized, it becomes a loose body in the knee joint with the resulting changes in the joint due to the presence of the foreign body. In such conditions—I have seen two—the fragment displaced can be recognized by the X-ray and should be removed or replaced. In one case the shell of bone was too thin to permit of fixation, and it was removed through an internal lateral incision close to the patella, exposing the joint. In the second case the fragment had a triangular shape with its apex toward the fracture line. A small drill was passed through the patella and through the apex of the fragment in such a manner that when a kangaroo tendon suture was passed and tied on top of the patella, it kept the fragment in close apposition to the remaining fragments.

The second type is fracture by indirect violence, and the essential feature of the lesion is the tear in the lateral expansion of the knee joint and more or less wide separation of the patellar fragments. Lesions of this type are always submitted to operation.

Immediately after the injury the knee should be bandaged with some form of elastic bandage, placed in a tin gutter splint in full extension, and ice bags placed over the knee for at least 48 hours, after which time the ice bags may be removed.

Operative intervention should be undertaken on the fifth to the seventh day, at which time the joint has passed the stage of exudative reaction, and troublesome exudation into the joint need not be feared after operation.

After the proper preparation the skin is incised in the long axis of the leg down to the seat of the fracture, and the skin and fat retracted to expose the tears in the lateral expansions. Two bone hooks are then used to separate the fragments more widely and all blood clots and fibrin are washed out of the joint by saline irrigation. Sponging and wiping of the joint are to be avoided.

For fixation the method advocated by Blake is by far the best. I have never used any other, and in a large number of cases have never failed to obtain and maintain complete reduction of the fragments.

The essential feature of this operation consists in 2 kangaroo sutures passed through the tendon as close to the patella as possible, hugging the bone, and passing down to, but not through, the synovial membrane. One suture is placed on each side, and when these are tightened the fragments will be brought into close apposition. If such apposition is not obtained, the sutures have not been correctly placed. They should not be tied until the lateral expansion is sutured.

The torn tendinous expansions are then sutured with fine (No. 0 chromic gut. Two bone hooks are inserted into the upper and lower ends of the patella and the bone drawn closely together. The two kangaroo sutures are then tied, and a few sutures placed to approximate the torn fibers of the periosteum.

The wound is then closed with interrupted plain gut subcutaneous sutures and skin sutures of silk worm-gut or horsehair, without drainage, and dressed. A stout moulded plaster splint is placed along the posterior aspect of the leg from the gluteal fold to 3 or 4 in. above the tip of the external malleolus, and bandaged firmly in place with muslin bandages passed in a double figure-of-eight above and below the patella.

On the seventh day the wound is dressed, the stitches removed, and the leg re-bandaged with muslin and starch bandages, and the patient is allowed up on crutches. Two weeks after the first dressing, 3 weeks postoperative, the leg is baked and massaged daily with lateral movements of the patella. In the fourth week postoperative, gentle passive movements in flexion are begun after the baking and massage, and are gradually increased.

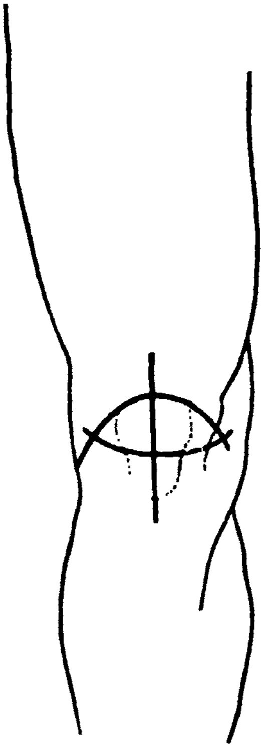

Fig. 14. Lines of Incision for Fracture of Patella.

The posterior splint is worn for 8 weeks, is then removed at night and while sitting about or walking in the room, but is worn while walking about the street for 10 weeks. From the eighth week the patient is encouraged to move the leg actively at the joint by allowing the foot and lower leg to extend over the edge of a table and using the weight of the leg to produce flexion. Flexion to a right angle may thus be obtained at the end of the tenth week, and full motion within a very short interval after that.

Circular sutures passed about the patella, silver or other metal sutures passed through drill holes in the bone are other methods of internal fixation.

The injection of various substances (2 per cent. formalin in glycerin—Murphy; nucleinic acid, etc.) to prevent infection is entirely unnecessary. Under the proper precautions infection does not occur.

Operative Treatment for Old Fractures of the Patella.—The success of any operation for an old fracture of the patella depends upon the contraction of the torn lateral expansions which are found at operation. If these are freed and found to be too small to permit of flexion of the knee (i. e. the narrowed capsule is not sufficiently large to permit the condyles of the femur to move in it), any operation which does not correct this feature of the case will be a failure in so far as subsequent joint function is concerned. Hence, before any type of operation is considered, the lateral expansions and the capsule must be freed. If these are sufficiently large to allow for flexion, the patellar edges may be freshened and approximated by wire mattress sutures passed through drill holes in the bone. For this purpose copper wire, such as is used by dentists, has proven more satisfactory than silver wire. Two bone hooks placed above

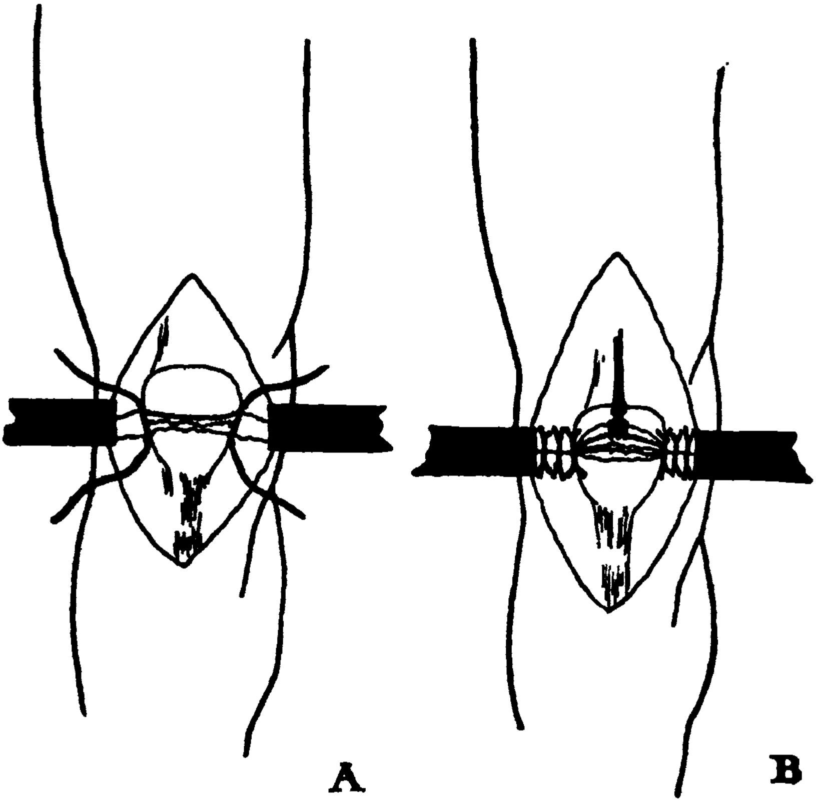

FIG. 15.—LINE OF INCISION AND METHOD OF SUTURE IN FRACTURE OF PATELLA. A shows the method of placing the two kangaroo tendon sutures through the fascial expansion hugging the patella. B shows the sketches tied. The periosteofascial flap over the patella is retracted to show the approximation obtained in the patella fragments. Note the long upper flap which overlaps the line of fracture.

and below the fragments will aid in drawing the bones together, and will hold them fixed while the wire suture is being tied.

Closure of the lateral expansion is made as in recent fracture, and the leg is dressed in the same manner.

When the fragments cannot be approximated, and when the lateral expansions have contracted so that readjustment of the normal conditions is not possible, the plan of attack must be variously modified (Quenu et Gatellier, 15).

Numerous operative expedients have been devised to meet the existing conditions. These consist in:

1. Lengthening the quadriceps by V-shaped incision in the muscle, transverse section of the muscle, and the 2-stage operation of Lister and Pringle: First stage, wiring the patella after pulling it down as far as possible; second stage, coaptation of the fragments by wire suture (McEwen, Diffenbach, etc.).

2. Separation of the tibial tubercle and its displacement upward (Poncet, Bergmann) and re-attachment to upper margin of the tibia.

Keen (5) combined the above two methods successfully.

3. Plastic operations: Autoplastic bone flap turned from below upward (Wolf, 20); osteomuscular flap turned from below upward (Rosenberger, 17).

4. Excision of the patella: Excision of the upper fragment with lengthening of the quadriceps tendon (Chaput, 1).

Total excision of the patella was successful in one of my cases in which the marked retraction of the upper fragment and the contraction of the lateral expansion were such that no other procedure seemed likely to succeed. After exposing the fragments and freeing the lateral expansions and the 2 fragments, a gap of 5 in. existed. The 2 fragments were then excised and a flap composed of deep fascia of the thigh and a musculotendinous flap from the quadriceps, vastus externus, and internus was turned down and sutured to the lower lateral expansion and to the patellar tendon below by a fine kangaroo tendon. The resulting joint motion was very satisfactory—flexion to beyond a right angle and complete extension—with a stable joint in all positions. For purpose of exposure a long oval flap was made in this case. A long straight incision down the leg is preferable because sloughing of the lower margin of the oval flap occurred and delayed the healing.

FRACTURES OF THE LOWER LEG

The treatment of fractures of the bones of the leg is dependent upon the degree of displacement in the tibial fragments, the type of the fracture, and the amount of reduction obtained by manipulation under an anesthetic.

Avulsion of the Tubercle.—Avulsions of the tubercle of the tibia in which the displacement cannot be corrected or in which there is marked rotation of the fragment are best treated by fixation of the avulsed tubercle by periosteal suture or by direct fixation by a screw or nail. The incision to approach this region is best made from the inferior internal aspect of the patella downward,

internal to the tubercle, and forward across the skin below the tubercle with retraction of the flap outward.

Fractures of the Upper End.—Fractures of the tuberosities of the tibia, external and internal, and T and Y fractures of the upper end of the tibia with marked displacement should be operated upon in suitable cases and the fragment or fragments fastened in place by a suitable screw, by screw and staples, or by a plate, if the latter seems more advisable (Fig. 2).

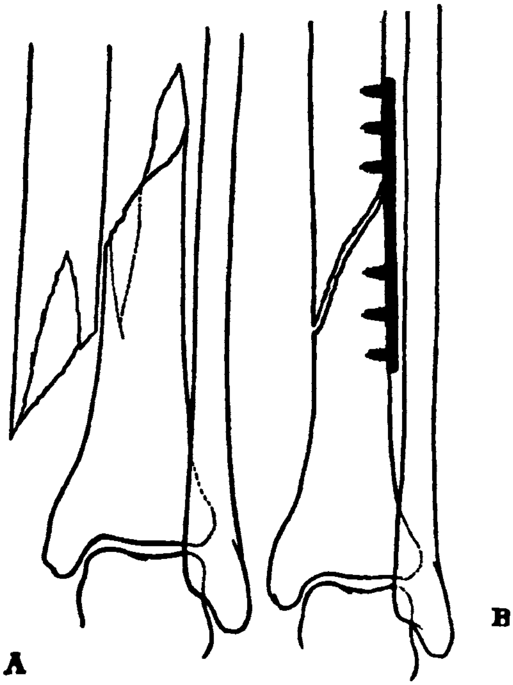

Fig. 10.—Spiral Fracture of the Tibia. Three weeks old, N. Y. Hospital. A—Best reduction obtained by manipulation, etc. The sharp lower end of the upper fragment was caught in the skin. B—The same after open reduction and fixation of the fracture by steel plate. Note the position of the plate under the tibialis anticus muscle.

The coincident fracture of the upper end of the fibula needs no treatment unless there is coincident injury to the anterior tibial nerve either by pressure of the fragment or by inclusion of the nerve in the callus. In either case the nerve should be exposed and the cause of the pressure removed.

Fractures of the Shaft of the Tibia. Due to the great variation in the type of the lines of fracture and the great variability in the degree of displacement, it is difficult to formulate the types necessitating operation. In general it may be said that all cases which cannot be properly reduced, and so maintained, need operation. The greatest difficulty occurs in the cases in the lower third with a complicated line of fracture, and operation is more frequently required in that region than elsewhere in the bone. Double fractures of the bone are best treated by open operation.

The types of internal fixation most satisfactorily employed are plates, intramedullary bone splints, and circular ligation of the bone (Fig. 5).

Care should be taken in placing non-absorbable material over the anterior surface of the bone just beneath the skin, as it is apt to produce trouble in this location. Plates, etc., should be placed on the external lateral surface beneath the tibialis anticus or on the internal aspect beneath the muscles.

Correct anatomical replacement in this bone is much more likely to produce a satisfactory leg than occurs with improper reduction, and the time of the repair process is distinctly shortened.

COMPOUND FRACTURES.—In the vast majority of cases compound fractures of the tibia are most satisfactorily treated by open reduction. Unless there is some contra-indication (shock, coincident injuries of greater importance, etc.), the operative interference is best undertaken within the first 24 hours after the injury.

The type of internal fixation will vary with the character of the line of fracture. No fixation is required for those cases which do not show a tendency to become displaced after the reduction. Certain cases may be suitably fixed by absorbable suture material (long oblique types).

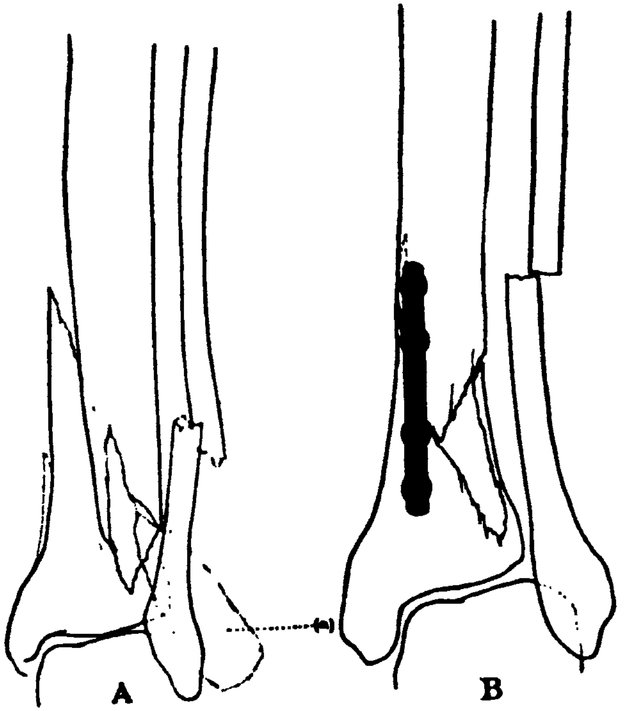

Fig. 17.—Complicated Fracture of Lower Third of Tibia and Fibula. N. Y. Hospital. A shows the character of the fracture. A large fragment (a) was split off from the lower fragment and driven down behind the external malleolus. It lay beneath the skin over the os calcis. B shows the same fracture after open reduction. Fixation by steel plate. The fragment shown in the other X-ray was removed.

When more rigid fixation is required, the external bone clamp (Freeman, Lambotte) or the bone plate of Estes is preferable.

I believe it is unwise to place an internal plate with screws, i. e. non-absorbable foreign material, in wounds of this kind, because of the increased danger of infection. If fixation can be obtained only by such internal plate fixation the wound should be left widely open and the plate removed as soon as the X-ray shows sufficient repair.

The advantage of the external clamp lies in its easy removal as soon as the leg is united firmly enough to dispense with this type of fixation. Furthermore, the dressing of the actual wound of the soft parts is considerably easier.

The extent of wound closure will depend upon the amount of injury to the soft parts. After thorough saline irrigation the wound may be loosely sutured in cases in which the injury to the skin and soft parts is slight (compounded from within out). In extensive laceration of the soft parts wide open dressing of the wound with saline solution is to be preferred, with secondary approximation of the wound edges after granulation has occurred.

Obviously cases in which the laceration of the soft parts is so extensive that the circulation to the distal parts is destroyed require amputation.

The subsequent treatment naturally will depend upon the presence or absence of infection in the wound. The leg should be elevated at an angle of 45°, and care should be taken to avoid any constriction of the leg by retaining splints or bandages.

In certain cases in which the exudative reaction in the leg shows signs of becoming excessive ice bags placed over the thigh in Scarpa's triangle may aid in restricting this reaction, or at least may render its onset more gradual. Ice bags should not be placed over the injured region under any consideration.

Fractures of the Lower End of the Tibia and Fibula.—Open operation is rarely necessary for fractures in this region which have received proper treatment originally. Should interposition of the periosteum or rotation of a fragment occur, an open incision is indicated.

In compound injuries (Pott's fracture, etc.) involving the ankle joint, open operation is usually indicated, especially in those cases in which dirt and other foreign material have entered the joint. Since infection and ankylosis are so common a result of such injuries, and drainage of the ankle joint is relatively difficult, the removal of the astragalus, as suggested by Bolton, is the method of election for those cases which, from the beginning, seem likely to become infected, and as a method of drainage when infection has occurred. Early removal of the astragalus before infection has become established has proven the more satisfactory method of treating this complicated injury and the after-result has been more satisfactory.

In old fractures of the lower end of the tibia and fibula by forced pronation and abduction of the foot, in which the deformity has not been corrected, open operation is indicated.

The operation of election for this condition is that described by Stimson. Two lateral incisions are used. The first is an external one over the anterior aspect of the fibula, extending about 3 in. beyond the tip of the external malleolus upward on the leg, and curved forward on the dorsum of the foot about the same distance. Through this incision the fracture line in the fibula is exposed and refractured along the line of fracture by a thin osteotome and any excess of bone removed.

When this step is completed an incision is made over the tibial aspect of the ankle extending from about 3 in. above the malleolus and passing downward just in front of this process to the tubercle of the scaphoid. Through this incision the lesion to the internal malleolus is approached, the line of fracture cut with an osteotome, and the lower end of the tibia freed by displacing the ankle back and out so that the lower end of the tibia is projected through the wound. The astragalus is liberated and any new bone on the posterior surface of the tibia rongeured away. When these steps are completed the foot should and can be easily replaced in its proper relationship to the leg. The wound is loosely closed without drainage and placed in appropriate moulded splints.

The restoration in shape is excellent by this method, and the pain usually present before the operation is relieved. The functional improvement is variable and depends upon the age of the patient and upon the proper after-treatment, but in most cases is an improvement over that existing before the operation.

FRACTURES OF THE TARSUS AND METATARSUS

Fractures of the Astragalus.- The displacement and type of fracture should be studied by careful X-ray photographs, preferably stereoscopic. Should these show marked degrees of displacement, etc., the treatment should be by open operation.

Fractures of the upper articular surface require removal of the displaced fragment. Fracture through the neck may be treated by replacement of the head and suture of the fragments, or if the head is completely detached, it should be removed. Crushing fractures with comminution are best treated by removal of the entire bone. A similar procedure is likewise preferable for compound fractures of the astragalus.

Fractures of the Os Calcis. Of the fractures of this bone only those of the body behind the sulcus peronei are suitable for operation, and these only when other methods have failed to bring about reduction. The chief displacement is that of the posterior or heel fragment upward by the pull of the gastrocnemius. When a fragment of the tuberosity of the bone or the entire tuberosity is thus pulled away, it may be sutured in place by kangaroo sutures passed through holes in the bone and tied after the foot has been carried into full plantar flexion. Should only a scale of bone be torn off, the suture should pass through the tendo Achillis, and the approximation obtained in that manner together with periosteal suture about the fragment.

When a large portion of the bone is broken off and displaced it may be reduced and fixed by a metal screw, nail, ivory, or bone pin carried through from the heel to the center of the bone beneath its superior articulating surfaces. Care must be taken to countersink the head of the fixation screw or pin so that it does not project above the surface of the bone, otherwise the skin overlying it will become involved and ulcerate by reason of the pressure against it.

The placing of the incision for the operation is important, inasmuch as pressure against the scar may be troublesome.

The most satisfactory line of incision consists in a vertical incision along the outer side of the tendo Achillis down to the sharp edge of the plantar skin,

continued horizontally around the heel, with dissection of the flap and its retraction toward the inner side of the foot. Care should be taken to hug the bone in this procedure so as not to interfere with the skin circulation of the heel flap. If this is done there is little danger of necrosis of the skin over the heel, and the scar is submitted to a minimum of pressure at a later date.

Other incisions are a vertical incision directly over the tendon down to the bone, and a semilunar incision to turn the whole heel flap back.

Fractures of the Tarsal Scaphoid.--In 2 cases Deutschlander (4) removed the bone with satisfactory result.

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CHAPTER VI

AMPUTATIONS

H. H. M. LYLE

Any surgical operation which involves the removal of the whole or a part of a limb is an amputation. For convenience, amputations are divided into two classes: amputations proper, when the extremity is severed in its bony continuity; and disarticulations, when the removal takes place through the joint.

DEVELOPMENT OF DIFFERENT TYPES OF AMPUTATION

The two fundamental incisions from which all others can be developed are the transverse circular and the oblique or oval. In the transverse circular the skin incision is perpendicular to the long axis of the limb; in the oblique or oval it is at an obtuse angle.

Transverse Circular Method (Fig. 1).—The oldest of all amputations is the circular. As practiced by Celsus, it consists of a simple transverse incision through the healthy tissues. It can be readily seen that this method provided no adequate covering for the bone and was consequently not suited to the cases in which primary union was desired. This defect in the Celsian method was overcome by Jean-Louis Petit of Paris (1718) and Cheselden of London (1749). They laid down the general rule that the incision should be made in 2 steps. The skin and superficial fascia were first divided and retracted, and the muscles were then cut through at the highest possible level. A. Louis of Paris (1752) rejected this method and returned to the Celsian incision plus a high division of the bone. Technical improvements were added by Alanson of Liverpool (1779) and Boyer of Paris. The circular method as practiced to-day follows closely the technic of B. Bell and Hey. Hey of Leeds called his method the "triple incision": The first incision divided the skin and fascia, which were dissected up for a sufficient distance; a second incision divided the muscles to the bone; the muscles were then separated from the bone, and the bone sawn through at a still higher level.

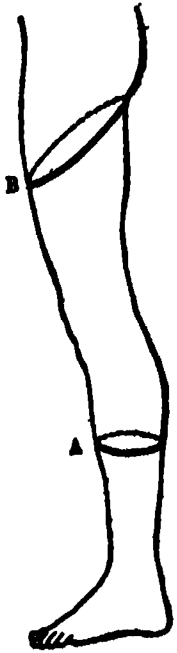


Fig. 1.—Fundamental Type: Circular Incision. A, Transverse circular incision (transverse incision). B, Oblique circular incision (oblique incision).

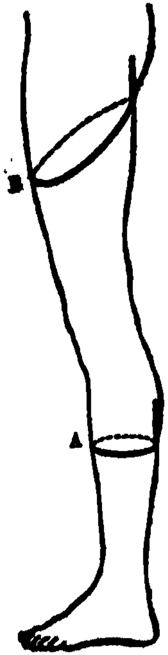


Fig. 2.—Addition of a Longitudinal Incision to Simplify the Operation. A, Transverse racket. B, Oblique racket.

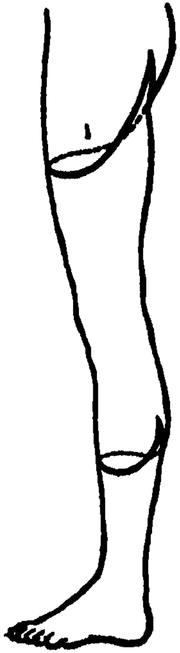


Fig. 3.—Angles of the Racket Incision Rounded off so as to Allow of the Incisions Being Made More Rapidly by One Sweep of the Knife; Lanceolate Incision. (Oval.)

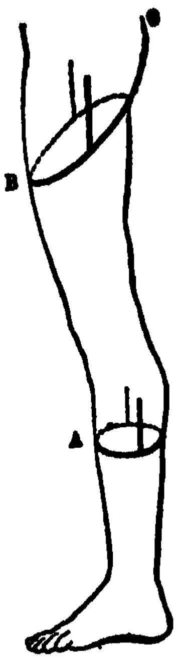


Fig. 4.—Two Longitudinal Incisions added to the Circular Incision: Rectangular Flaps. A, Rectangular flaps. B, Unequal, rectangular flaps.

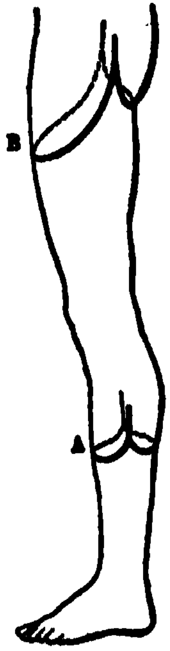


Fig. 5.—Angles of the Rectangular Flaps Rounded Off; Rounded Flaps. A, Equal rounded flaps. B, Unequal rounded flaps.

ADVANTAGES.—The advantages on the circular method are simplicity, speed of performance, the least sacrifice of limb, minimum damage to nutrition and circulation, and smallest wound surface exposed to infection.

DISADVANTAGES.—The disadvantages of the circular method are the position of the cicatrix over the end of the bone; the difficulty in a conical limb of separating enough skin to cover the bone, or in a muscular part of the limb of obtaining proper exposure for the high section of the bone; and its inadaptibility for injuries where the destruction of tissues is unequal.

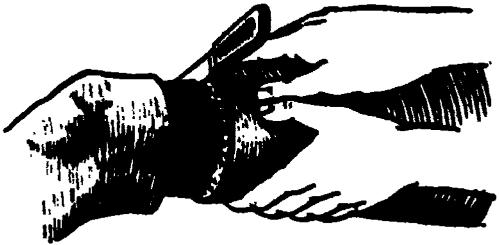


FIG. 6.—TRANSVERSE CIRCULAR INCISION; METHOD OF RETRACTING SKIN AND POSITION OF KNIFE. (Kocher.)

TECHNIC.—The skin and superficial fascia are divided at right angles to the long axis of the limb; the skin retracted (Figs. 6, 7, 8) and dissected to the required distance; the superficial muscles divided and allowed to contract; and the incision carried down to the bone in such a manner that a funnel-shaped wound is made. The bone is then treated according to the osteoplastic, aperiosteal or tendinoplastic methods. In order to obtain sufficient covering for the bone the following points must be kept in mind: The skin must be divided at a distance below the point of bone section equal to the diameter of the limb at the saw line; in the upper arm where the retraction is the greatest, 1½ diameters must be allowed.

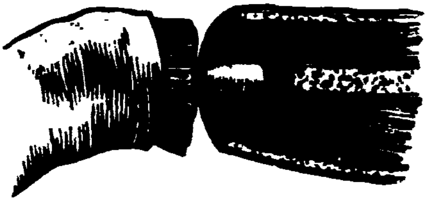


FIG. 7.—TRANSVERSE CIRCULAR INCISION. Sagittal section showing cone which is left after sawing through the bone. (Kocher.)

Oblique or Oval Method (Fig. 1).—This method was first described by Sharpe of London (1739), used by Blasius of Amsterdam (1838) and perfected by Soupart of Liège (1847).

ADVANTAGES.—The advantages of the oblique method over the transverse circular are a higher access to the bone, ebtter position for the cicatrix, possibility of utilizing tissue which would otherwise be sacrificed, and a wider range of adaptability.

DISADVANTAGES.—The disadvantages of this method are a more extensive wound surface and a greater damage to the nutrition and circulation of the tissues.

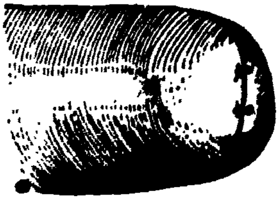


FIG. 8.—POSITION OF THE SUTURE LINE IN A TRANSVERSE CIRCULAR INCISION.

TECHNIC (FIGS. 9, 10, 11, 12).—Kocher is a strong advocate of this method. The following is his description:

"The oblique incision is the most important and most universal method of amputations in simple cases. In this method the upper and lower ends are indifcated by making short incisions into a fold of skin raised up between the finger and thumb, the distal incision being made at right angles to the surface, the proximal one parallel to the surface. The upper end lies at the level where the periosteum is to be divided, the lower end lies at a distance below it equal to the diameter of the limb. After dividing the skin and fascia, the lower ellipse of skin is seized with the left hand and drawn upward, and the muscles are divided down to the bone, the edge of the knife being directed toward the bone so that a flap is formed which increases in thickness toward its base. The periosteum is divided transversely where the incision reaches the bone and, as in the transverse circular incision, is separated upward so that it may cover the sawn surface. The musculocutaneous flap is now folded over the wound."

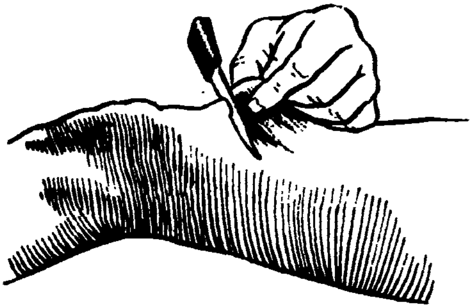


FIG. 9.—OBLIQUE INCISION. The lower end made by cutting across a fold of skin raised up between the finger and the thumb. (Kocher.)

The Racket Incision. The racket incision, introduced by Malgaigne of Paris (1837), is formed by adding a longitudinal incision to the oblique or transverse circular. The length of this longitudinal incision is determined by the height at which the bone is to be sawn (Fig. 2). This incision is the best type of amputation to retain useful muscles in a stump. Kocher's principle of a selective incision should be used and the handle of the racket placed over an intermuscular septum. This septum should mark the "neutral zone" between two areas supplied by different nerves.

The Lanceolate Incision (Fig. 3).—This is obtained by rounding off the angles of the racket incision. It was used by Conrad Langenbeck of Göttingen (1807) for the metacarpus, by Guthrie of England (1815) for the shoulder, and also by Abernethy for the hip. The credit for the generalization of the method belongs to Scoutetten (1827).

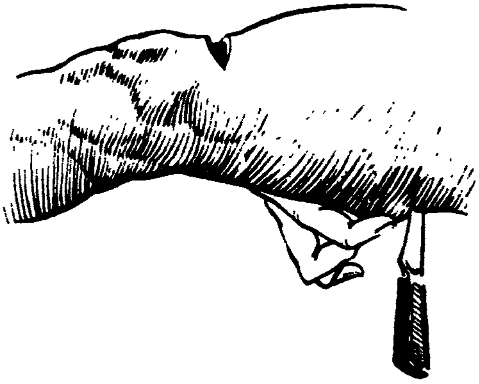


FIG. 10.—OBLIQUE INCISION. The upper end made by cutting across a fold of skin raised between the finger and the thumb. (Kocher.)

Flap Methods (Figs. 4, 5).—These can be developed from the transverse circular or the oblique by the addition of 2 longitudinal incisions. Young of Plymouth (1679) credits Lowdham of Exeter with inventing the single flap of skin and fascia. Verduin of Amsterdam (1696) employed a musculocutaneous flap cut by transfixion. Ravaton of Landau (1739) cut double square flaps, equal to half the thickness of the limb. Vermale (1765), a French surgeon in the service of the Elector Palatine, improved Ravaton's technic by fashioning rounded or oval flaps, these flaps being cut by the transfixion method. In the further development of the flap operations the names of Guthrie and Liston of England; Dupuytren, Roux and Larrey of France; and Klein and Conrad Langenbeck of Germany are intimately connected.

Flaps are cut by (a) *transfixion* and by (b) *dissection*. The general rule to be observed is that the length of the combined flaps should be equal to 1½ the diameter of the limb at the saw line.

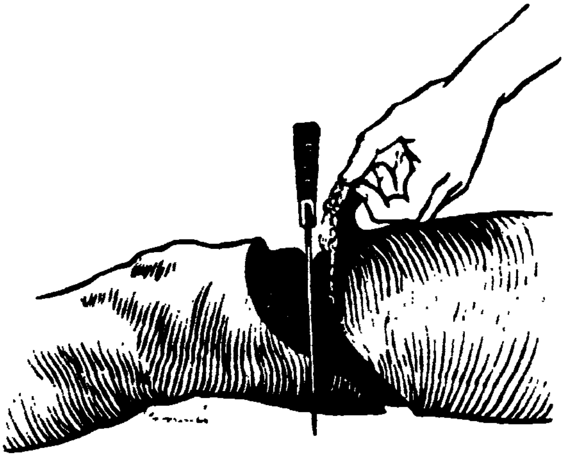


FIG. 11.—OBLIQUE INCISION. Position of the knife in order to gradually carry the incision deeper through the soft parts of the flap. (Kocher.)

(A) TRANSFIXION. Formerly this was the popular method; today its application is limited to those cases in which the saving of time is essential and to flaps where many tendons have to be severed. If an attempt is made to cut from without inward, the unequal contraction and rolling of the tendons under the knife will result in an uneven section. By inserting the knife between the bone and tendons, and cutting up through them with a rapid sawing motion, this difficulty is overcome. In this method a double-edged knife is thrust through the skin, across the surface of the bone, on a level with the proposed bone section; by a steady sawing motion the knife is carried downward to the desired distance, then outward in an arched manner.

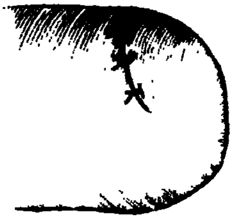


FIG. 12. POSITION OF THE SUTURE LINE IN AN OBLIQUE CIRCULAR AMPUTATION.

(B) DISSECTION.—The flaps are outlined by incisions passing through the skin and subcutaneous tissue. The skin is freed and retracted, the knife carried obliquely through the muscles to the bone, and the muscles severed in such a manner that the thinnest portion is adjacent to the cutaneous portion of the flap and the thickest portion is at the base.

ADVANTAGES.—The advantages are that the flap can be planned to save tissue; with unequal flaps the cicatrix is not subjected to terminal pressure; a ready access to the bone is provided; and the best available covering can be selected from any aspect of the limb.

DISADVANTAGES.—The disadvantages are the damage to the circulation and nutrition of the tissues; and the large area of tissue exposed to possible infection.

THE GOAL OF ALL AMPUTATIONS

After the preservation of the life of the patient, the goal of all amputations is the production of a useful stump. To obtain this, 3 cardinal points must be observed: (1) correct treatment of soft parts; (2) correct treatment of the bone; (3) prevention of stump atrophy.

1. **Treatment of Soft Parts.**—A well-nourished skin flap accustomed to pressure should be used; the edges of the wound clean-cut; absolute hemostasis secured; nerves cut short to prevent their being enmeshed in the cicatrix; new insertions provided for the muscles, or if this be impracticable, they should be sutured over the end of the bone; the muscular, fascial and skin layers sutured without tension, care being taken to prevent their adherence to one another, and the cicatrix so placed that it will not be subjected to pressure. J. N. Jackson (Figs. 13, 14), in dividing the soft parts, cuts through the skin; after this retracts, he incises the deep fascia, reflecting this with the skin flap. The muscles are cut obliquely toward the bone and the wound is closed by accurate layer sutures, particular attention being paid to the approximation of the fascia.

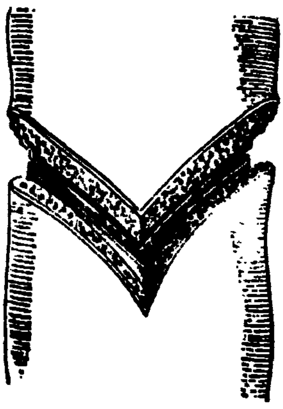


FIG. 13.—JACKSON'S METHOD OF CUTTING AMPUTATION FLAPS. Flaps of skin, superficial and deep fascia, are dissected back by cutting into the muscle substance.

2. **Treatment of the Bone.**—In amputations there are 4 methods of treating the bone: the osteoplastic, tendinoplastic, periosteal and aperiosteal. **The osteoplastic is the ideal method, but requires ideal conditions. The tendinoplastic is of limited usefulness. The periosteal, although employed by the majority of surgeons of this country, is inferior to the other methods and should be abandoned. The aperiosteal is the most universally applicable and the most practical.**

THE OSTEOPLASTIC METHOD (Fig. 15).—The osteoplastic method aims to cover the raw bone surface and medullary canal by a bone flap whose periosteum has a normal connection; in this way the possibility of painful bony outgrowths developing from the periosteum and marrow is avoided. Pirogoff's operation (1852) furnished an osteoplastic stump which was capable of bearing direct weight. Contrary to what most writers have claimed, Pirogoff attached only a secondary importance to the osteoplastic feature, his main endeavor being to devise a procedure which would overcome the difficulties encountered in dissecting the heel flap of a Syme's operation. Gritti (1857) introduced his osteoplastic transcondylar amputation. The development of the modern osteoplastic method, however, is directly due to the efforts of Bier (1892) and his pupils. Bier's original view, that the raw surface of the bone and medullary canal remained tender, was erroneous. He now acknowledges that in a large measure, the tenderness is due to the irregular bony outgrowths from the periosteum and medullary cavity. Bier set the standard that all stumps, diaphyseal as well as epiphyseal, should directly support the whole weight of the body. Binnie claims that Bier's osteoplastic operation is needlessly complicated and difficult, and that all the advantages of this operation can be obtained by covering the cut end of the bone with a free bone transplant.

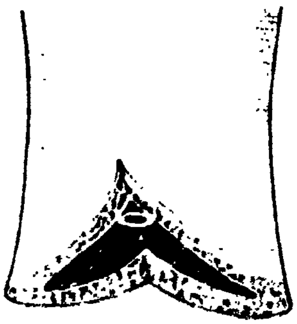


FIG. 14.—JACKSON'S METHOD OF CUTTING AMPUTATION FLAPS. The incision has been carried obliquely through the muscles to the bone.

THE APERIOSTEAL METHOD (HIRSCH-BUNGE) (Figs. 16, 17). The aperiosteal method aims to produce a painless supporting stump capable of early functional use. The result is obtained by the removal of a portion of the periosteum and bone marrow, combined with massage and early weight-bearing exercises. Hirsch's investigations (1899) showed that in the old method of stripping up a periosteal cuff to cover the bone, many shreds of periosteum resulted. These shreds, still retaining their primitive osteogenetic function, produced painful bony spikes (Figs. 18, 12) which interfered with the early functional use of the stump. While by massage, exercises and graduated pressure many seemingly useless stumps could be made capable of weight-bearing, Bunge (1900) went a step further and advocated the removal of 1 to 2 cm. of the periosteum and the scraping out of the bone marrow for a similar distance. The correctness of Hirsch's and Bunge's views is substantiated by v. Eiselsberg, Kocher, Moskowicz, Ranzi, and Witzel. This method had an extensive practical test in the Russian-Japanese and Balkan Wars. At the International

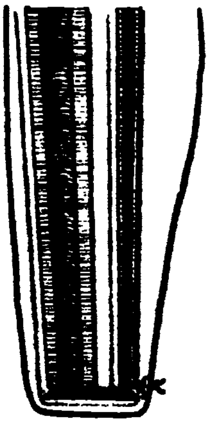


FIG. 15.—OSTEOPLASTIC METHOD.

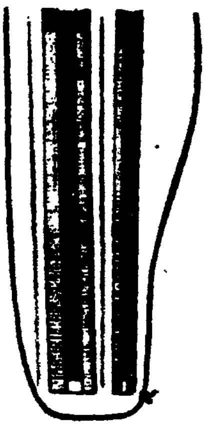


FIG. 16.—APERIOSTEAL METHOD.

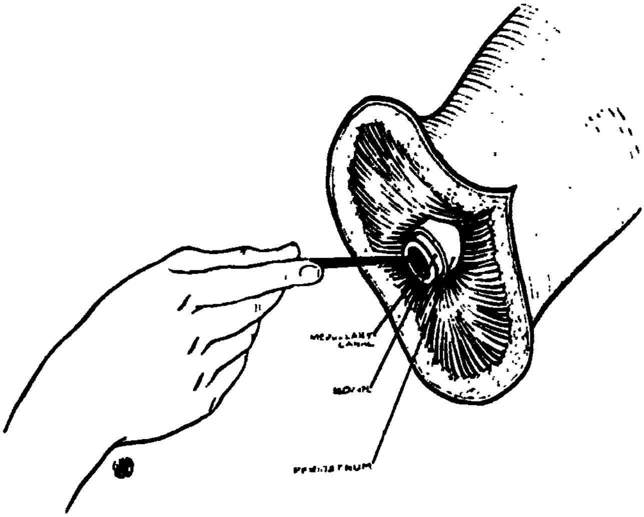


FIG. 17.—METHOD OF TREATING THE BONE IN AN APERIOSTEAL AMPUTATION. (After Muller.)

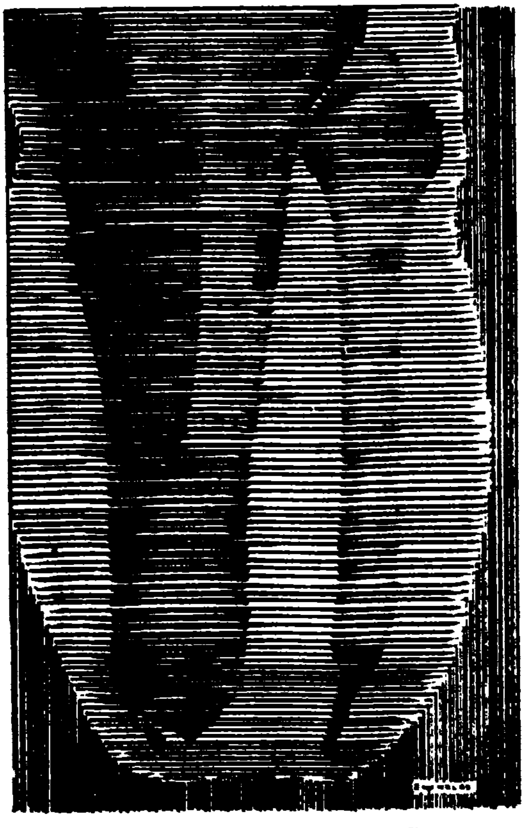


FIG. 18.—SHOWING BONY SPICULES RESULTING FROM A PERIOSTEAL AMPUTATION.

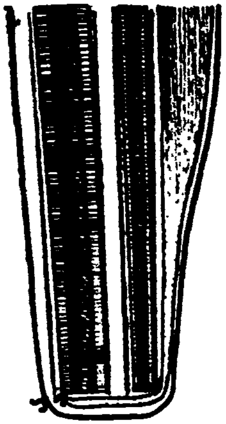


Fig. 19.—Tendinoplastic Method.

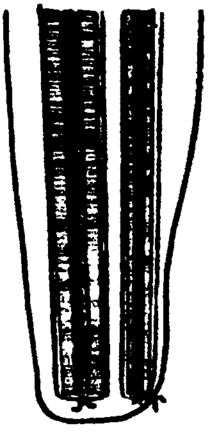


Fig. 20 Periosteal Method.

Congress of 1914, Ranzi (73), from von Eiselsberg's clinic, reported on the results in aperiosteal amputations of the leg. In 75 cases, between the years 1901-1913, the end results on 40 of these were obtained, 25 healed by primary union, 15 by secondary intention. In 31 cases an end-bearing stump was obtained, in 7 cases the result was fair, in 2 cases the stump was not end-bearing. In the 15 cases which healed by secondary intention 10 were completely satisfactory, 4 were fair and only 1 a failure. The ages of the patients varied from 20 to 80 years. The remarkable feature of this report is the number of successful stumps obtained in the infected cases. It is in just these cases that the periosteal method fails, as the inflammation leads to the production of exostoses. Salomon reports similar results, and concludes that the aperiosteal method should be the normal procedure in amputations.

TENDINOPLASTIC METHOD (DUVAL WILMS) (Fig. 19). The tendinoplastic method aims to cover the sawn bone by a broad tendon, which is stitched to the periosteum. This method is of limited application. Good functional stumps can be obtained, however, at the knee, ankle and humerus where the quadriceps tendon, tendo Achilis and triceps are available. It is of special value as a covering in finger and metacarpal amputations. Such stumps, when treated by the older method, often remain exceedingly sensitive.

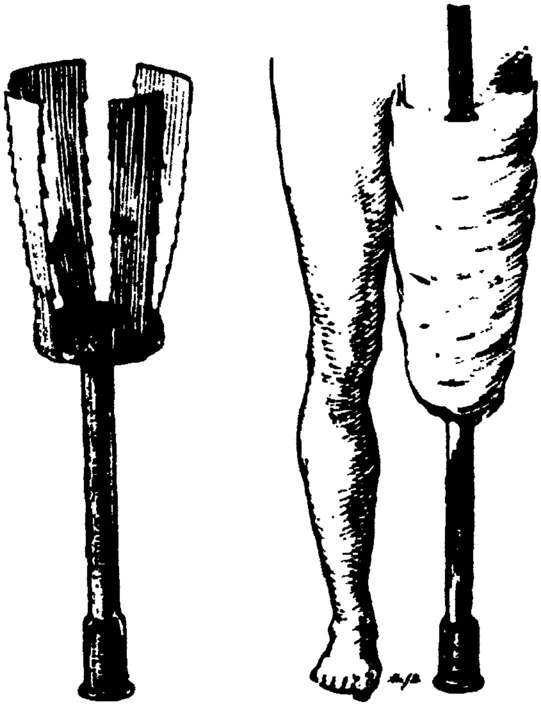


Fig. 21. Bier's Provisional Peg Leg. (Ritter.)

THE PERIOSTEAL METHOD (Fig. 20). The functional results of this

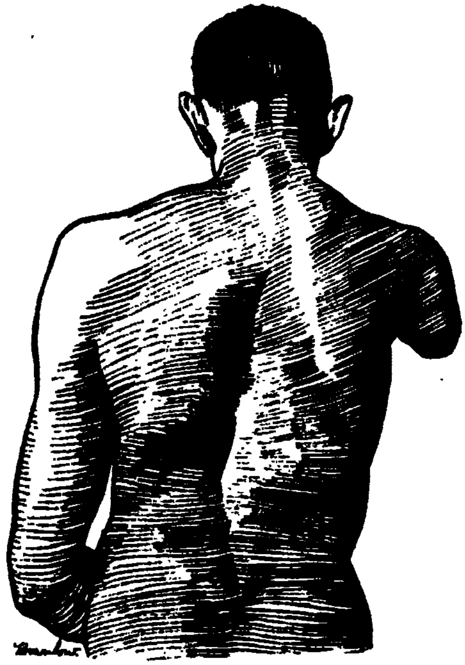


FIG. 22.—SCOLIOSIS AFTER HIGH AMPUTATION OF THE ARM. (Ritter.)

method cannot be compared with those obtained by the osteoplastic or aperiosteal methods. From practical experience we are firmly convinced that this time-honored method has outlived its usefulness and should be abandoned. In diaphyseal amputations performed according to this method a satisfactory end-bearing stump is rarely obtained, and in amputations through the shaft of the femur the results are notoriously bad (Figs. 126, 127). Cramer, in a series of 96 cases of amputations through the thigh and leg found 70 bad stumps, and only 2 capable of bearing direct weight. In a personal study of 13 amputations through the thigh we found only 1 end-bearing stump. These amputations were performed in New York clinics, and the majority of them by our ablest surgeons; the fault lay not in the technic of the operator, but in the method. Of these cases 12 healed by primary union, 1 by secondary intention; all had the usual artificial limbs applied at the end of 3 months. Brauning in 122 amputations of the thigh and leg found only a few with end-bearing stumps. Salomon and others report similar results.

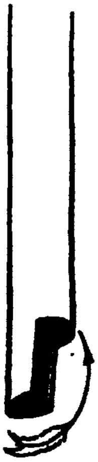


FIG. 23.—BIER'S METHOD OF TREATING THE NERVES IN AMPUTATION.

3. Prevention of Stump Atrophy. The prevention of stump atrophy is the third great principle in obtaining a useful end-bearing stump. The best formed stump, if not quickly put to use as a real support, may become atrophied and useless. As soon as the wound is healed, massage movements and graduated weight-bearing exercises must be commenced, and within a short time a temporary and then a permanent end-bearing artificial limb worn. The modern artificial limb, by distributing the weight to sides and other parts rather than to the end, causes atrophy and should not be used; the same advice applies to stump "shrinkers" and all other atrophy producing devices. **All stumps, according to Hirsch, should be treated as follows:** After operation elevate the stump; when the wound is healed give a dry massage twice daily, at the completion of which rub in a 2 per cent. solution of salicylic acid in olive oil; at night immerse the stump in a warm sodium carbonate bath;

protect the stump with cotton wool, place a box at the foot of the bed, make the patient press against it from 5 to 10 minutes 3 times a day, then 4 times, then every 2 hours, finally every hour. After each pressure treatment, energetic muscular movements with flexion and extension of hip and knee. The patient is now ready for the standing exercises and starts by resting the stump on a bran bag, at first on both legs, then on the stump alone; if there is no pain, fit the stump with a temporary peg leg (Fig. 21) and later with a permanent prosthetic appliance which should take the weight on the end of the stump. Care must be employed to prevent the occurrence of contracture or static deformities after amputations. In amputations of the thigh, if the patient uses crutches for some time, it will be found that the flexors have become contracted and the stump drawn forward, past the weight-bearing line. Before an artificial leg can be properly adjusted, the flexion contracture must be overcome by a tenotomy or a manual correction. A similar condition occurs at the knee. In high amputation of the upper extremity, especially in younger people, scoliosis (Fig. 22) may ensue if suitable exercises are not instituted to prevent it.

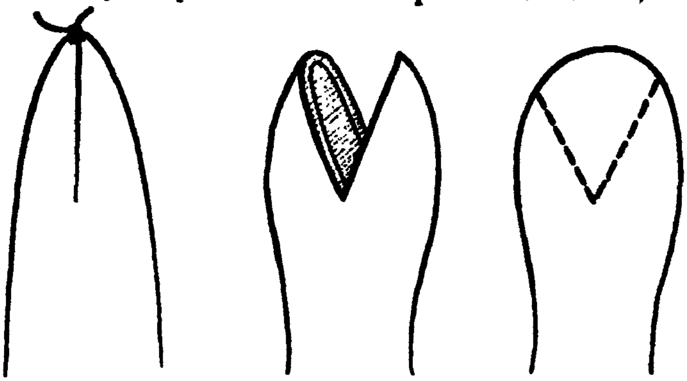


FIG. 24.—RITTER'S METHOD OF TREATING A CLUBBED NERVE.

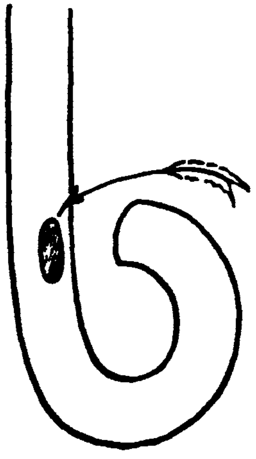


FIG. 25.—BARDENHEUER'S METHOD OF TREATING THE NERVES IN AMPUTATION.

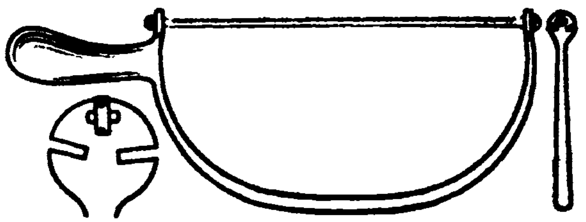


FIG. 26.—BIER'S MODIFICATION OF THE HELFERICH FRAME SAW. Method of using the frame saw to remove slices of bone. (Pels-Leusden.)

Summary.—Even at the present day much is still to be desired in the functional results. The osteoplastic, aperiosteal and periosteal methods are capable of yielding serviceable stumps if the operation is correctly performed, primary union obtained, and early functional use instituted. To obtain such perfect

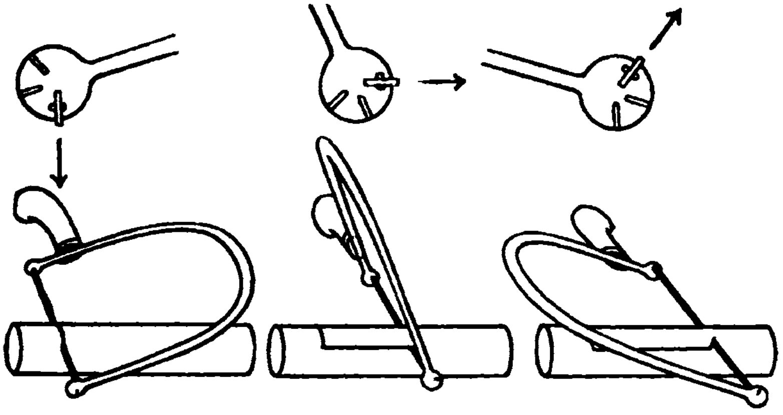


FIG. 27.—METHOD OF USING HELFERICH'S SAW. (Axhausen.)

results in all cases, ideal conditions must be present. In the face of complications in the healing, the aperiosteal method is the only one which furnishes a useful weight-bearing stump; in the osteoplastic, necrosis of the flap may take place; and in the periosteal, the inflammation leads to the production of exostoses. The aperiosteal is adaptable to all conditions of nutrition, whereas the osteoplastic method is contra-indicated in cases of doubtful circulation. Besides its wider range of usefulness, the aperiosteal method is far simpler to perform than either the osteoplastic or the periosteal. The same objections, but to a lesser degree, hold for the comparison of the aperiosteal and the tendinoplastic. An added advantage of the aperiosteal, the tendinoplastic and the osteoplastic over the periosteal is that any convenient skin can be used in the flap, as these methods do not of necessity require skin accustomed to pressure.

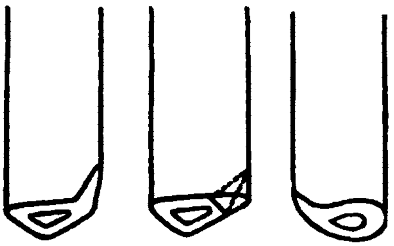


FIG. 28.—METHOD OF BEVELING BONY ANGLES.

We consider the aperiosteal method to be the safest and the simplest and to have the widest range of usefulness. In experienced hands and under ideal conditions, the osteoplastic gives splendid operative results. The periosteal should never be used. Any method may fail if stump atrophy is not prevented.

GENERAL PRINCIPLES UNDERLYING TREATMENT OF THE SKIN, MUSCLE TISSUES, NERVES, BLOOD-VESSELS AND BONES

The Skin.—The nutrition of the skin should be carefully preserved and due allowance made for its contractility. The nearer the line of amputation is to the trunk, the more marked is the retraction of the skin. The average shrinkage is about 1/3 of the length of the flap. The contractility is impaired by inflammation and edema of the soft parts. Where the skin is thin, adipose tissue lacking and fibrous connections to the underlying aponeurosis and bones exist—as at the knee—the retraction is scant. The skin in some regions is accustomed to pressure and consequently makes a good covering for a stump, as the skin of the heel, the front of the knee, the back of the elbow, palm, etc.

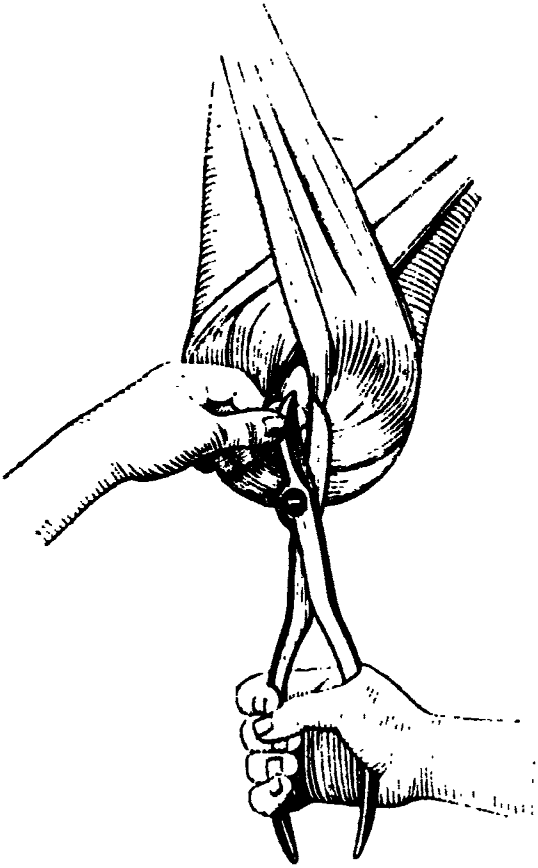


FIG. 29.—METHOD OF ROUNDING OFF SHARP BONY EDGES WITH LISTON'S BONE CUTTING FORCEPS. Steady the upper blade of the forceps with the thumb of the left hand, move the lower blade upward by a twisting movement of the wrist. This makes a round smooth edge.

The Muscles.—Muscular tissue is not very resistant to infection and should be gently and carefully handled. In estimating the degree of muscular retraction, the muscular development of the patient and the presence of atrophy and of inflammation must be considered. The flexors retract more than the extensors: those which are free between the origins and insertions—as the biceps, hamstrings, etc.—contracting the most: and those which have broad long attachments the least. Tendons should be cut clear across and not drawn out of their sheaths. Rioblanc and Koch-Dorpot were the first to call attention to the value of suturing antagonistic muscles over the stump.

The Nerves.—Nerve trunks should be "blocked" by an injection of 1 per cent. novocain solution before being severed. To prevent nerves from becoming enmeshed in the cicatrix, they should be drawn down, and 2.5 to 5 cm. (½ to 1 in.) trimmed away. Bier covers the cut end of the nerve by a plastic on the sheath (Fig. 23). Ritter removes a wedge-shaped portion of the nerve (Fig. 24) and sutures so that the nerve is inclosed in its neurilemma. Bardenheuer treats the nerve stump as shown in Figure 25, and then buries the stump in the muscle. Cushing's procedure of suturing two different nerve trunks together is not physiological.

The Blood-vessels.—Blood-vessels should be cut at right angles, the main vessels seized with artery forceps and separated from the surrounding tissue for such a distance that a ligature can be safely applied without danger of slipping. The larger branches are found in the intermuscular septa. If difficulty is experienced in properly ligating, an encircling catgut suture can be applied.

The Bone.—The bone should be treated by the osteoplastic (page 268), the aperiosteal (page 269), or the tendinoplastic method (page 271).

INSTRUMENTS

Knives and Their Handling.—A moderate-sized scalpel is preferable to a long amputating knife, as it can be directed with greater precision. In a few cases, where speed is the essential, the long knife is indicated. The Catlin double-edged knife is used in transfixion and in work between bones. In outlining a skin flap the eye must never be depended on; the principal guiding points should be indicated by scratch marks. The blade, not the point, should be drawn across the tissue with a free motion; the stroking and scratching dissecting-room movements must not be used. The skin is to be cut at right angles; the edge of the blade directed against the part that is to be discarded, never against the flap; scoring of the subcutaneous tissue and skin must be avoided, as the integrity of the skin depends on the blood-vessels ramifying in the fat. Care must be taken to preserve the blood supply of the flap, and in fashioning a long muscular flap it is wise to cut downward with the blood stream. For example, in cutting the plantar flap of a Lisfranc the knife cuts downward from the tarsometatarsal joint, hugging the plantar surface of the metatarsals and thus reducing the number of blood-vessels severed, the amount of blood lost, and the damage to the soft parts.

Handling of the Saw and Bone-cutting Forceps.—Bier's modification of Helferich's adjustable frame saw (Figs. 26, 27) is the most useful type. Place the heel of the saw on the cleared bone, draw it from heel to toe with a firm even pressure until a satisfactory guiding groove is formed, then saw through—applying the most pressure on the drawing stroke. Support the distal portion of the limb in such a manner that binding of the saw and splintering of the bone will be prevented. Smooth off the sharp edges of the sawn bone with a saw (Fig. 28), or with Liston's bone-cutting forceps (Fig. 29).

Retractors.—The soft parts can be held back by a sliding metal retractor (Fig. 30) or by means of a tailed retractor (Figs. 31, 32). The latter retractors are made from strong muslin and torn to fit the individual requirements.

HEMOSTASIS

Hemorrhage is prevented by the tourniquet, the forceps-tourniquet, digital compression, temporary ligation or clamping, preliminary ligation, or by planning the operation so that the severing of the main vessels is one of the last steps. Extensive oozing is prevented by coagulin (Kocher-Fonio).

Tourniquet.—The development of the tourniquet marks an important era in the history of amputation. Originally it was a simple band or fillet tied tightly about the limb above the site of amputation, the hemostasis obtained being uncertain and unsatisfactory. In 1674 the French surgeon Morel invented a simple device for increasing the safety and certainty of the compression. He passed a stick beneath the fillet and turned it around until the twisted fillet had produced the requisite pressure. This crude device of Morel's furnished the basis for the screw and band tourniquet devised by his illustrious countryman, Jean-Louis Petit (1718). *Petit's instrument* (Fig. 33) and its modifications apply a compression to the whole of the circumference of the limb and a local pressure to the main vessel.

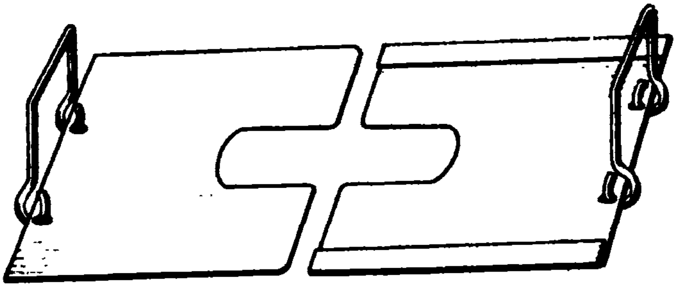


FIG. 30.—METAL RETRACTOR, OPEN.

METAL SCREW TOURNIQUET.—In the second type, as exemplified by the metal screw tourniquets of Lister (Fig. 34), Skey and Pancoast, no band is used; but an attempt is made to limit the pressure to the main artery.

ELASTIC TOURNIQUET OF ESMARCH.—The third type is represented by the elastic tourniquet of Esmarch. This is a revision to the original fillet type, but differs from it in that the compression is elastic. The Esmarch bandage and tourniquet (1873) accomplishes two purposes: The bandage expels the blood from the part that is to be amputated; the tourniquet prevents the entrance of any more blood into the vessels.

TECHNIC.—Elevate the limb from 4 to 5 minutes, then apply the stretched rubber bandage from the fingers or toes to the upper arm or thigh. Overlap each turn of the bandage to ½ its width. Carry the compression bandage up to the site selected for the application of the constrictor. This latter is a soft rubber tube, 140 cm. long, and having a diameter of 10 to 14 mm. Under continued tension, wind the constrictor around the limb a sufficient number of times to control the circulation. The correct measure of force is to be learned by practice. Too much pressure causes severe pain and may lead to paralysis. On the removal of the compression bandage the limb is bloodless. At completion of the operation apply pressure to the wound, elevate the limb, remove the constrictor, and wait for 5 to 10 minutes until the temporary paralysis of the blood-vessels disappears; attend to hemostasis and close the wound.

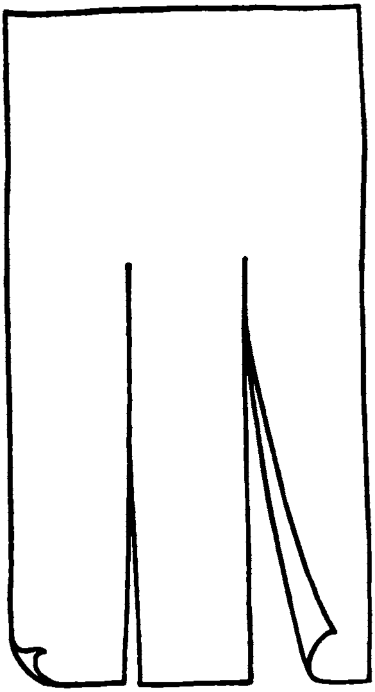


FIG. 31.—THREE-TAILED MUSLIN RETRACTOR.

CONTRA-INDICATIONS.—The compression bandage should not be applied over inflamed areas or over soft tumor tissue on account of the possibility of the pressure disseminating the infection or tumor cells. In thin people a prolonged application may lead to a pressure paralysis. Too long and too tight constriction leads to postoperative oozing. Where the compression bandage cannot be applied, hold the limb at right angles to the body for 5 to 10 minutes, then apply the constrictor. This method yields a fairly bloodless field.

PERTHES' TOURNIQUET. (Fig. 35).—The fourth and most modern type is the pneumatic tourniquet of Perthes (Tübingen). It consists of a broad, flexible, adjustable band encircling a hollow rubber cuff. The cuff is distended by means of an ordinary bicycle pump, and the amount of pressure indicated by an attached manometer.

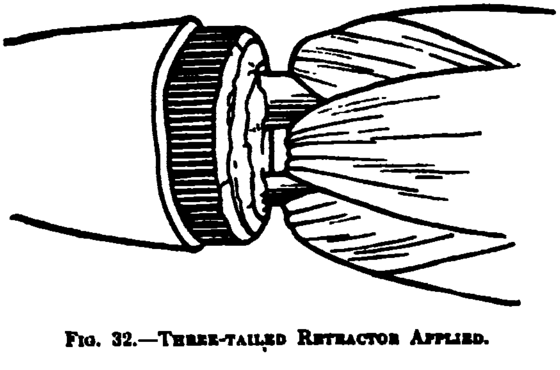


FIG. 32.—THREE-TAILED RETRACTOR APPLIED.

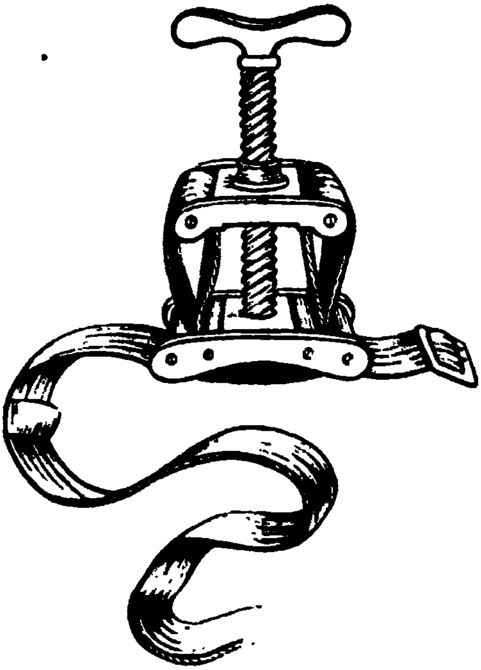


FIG. 33.—PETIT'S TOURNIQUET.

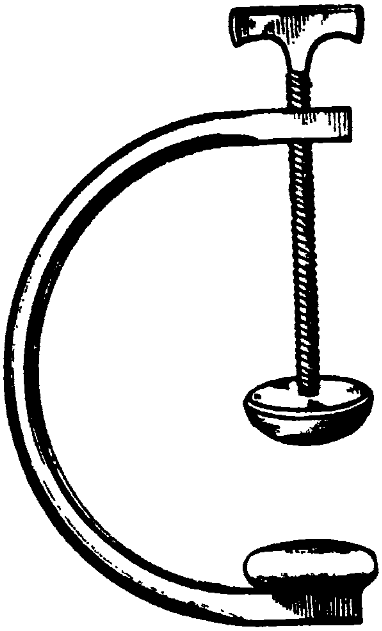


FIG. 34.—LISTER'S TOURNIQUET.

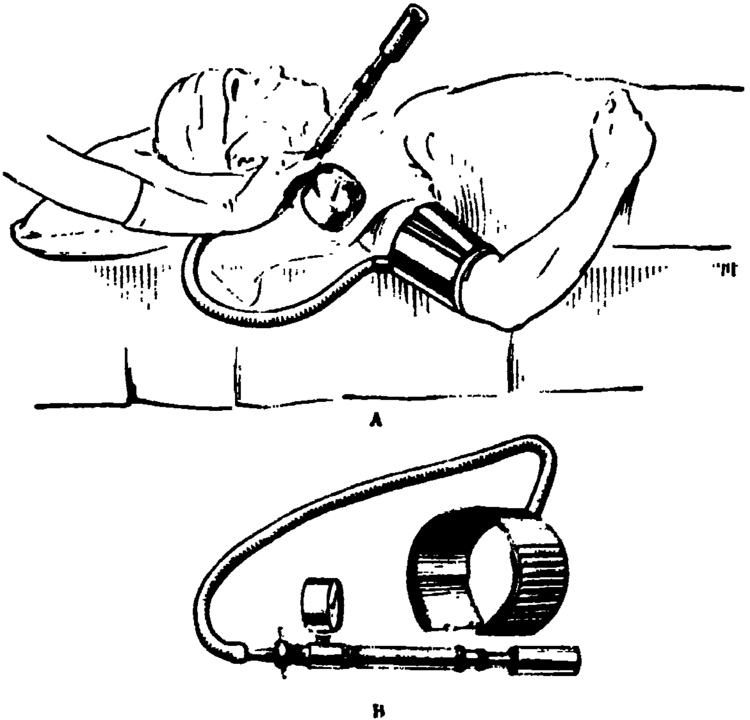


FIG. 35.—PERTHES' PNEUMATIC TOURNIQUET. A. Application of tourniquet. B. Tourniquet: an outer flexible metal band protecting a pneumatic cuff, a bicycle pump and manometer.

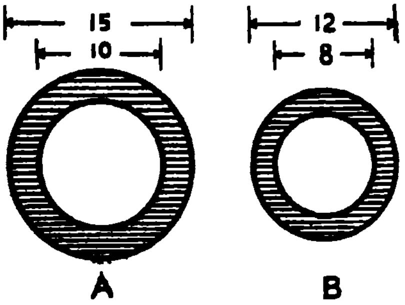


Fig. 36.—Cross-section of Rubber Tubing Used in Momburg's Method. A, For adults (15-10 mm.). B, For children (12-8 mm.)

Technic.—(1) Force the blood out of the extremity by applying an Esmarch bandage, or reduce the amount by elevating the limb. (2) Place the rubber cuff around the upper portion of the extremity, and secure it by the flexible metal band. (3) Distend the cuff by the air pump until 150 to 200 mm. of mercury is indicated on the manometer. For the average case, 150 mm. pressure is sufficient to shut off the blood stream; in cases of nephritis or arteriosclerosis where the general blood pressure is over 200 mm., 250 to 300 mm. may be required. The advantages are that it produces an even, comfortable pressure, which pressure can be altered during the operation if desired, that is, freed when the main vessels are secured; it can be loosened to detect the position of a vessel; it is adaptable to amputations under local anes-

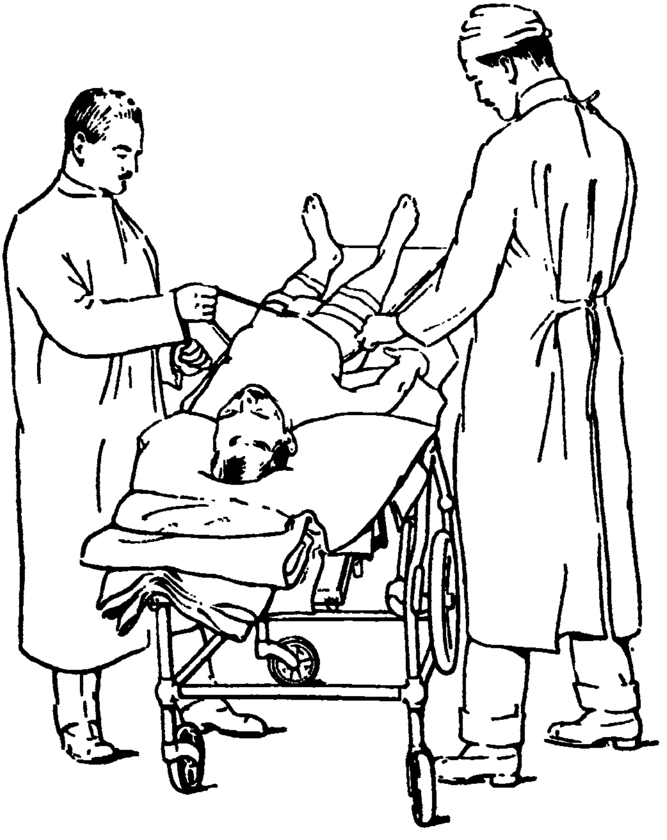


Fig. 37.—Momburg's Method of Controlling the Circulation in the Lower Half of the Body. Note elastic bandages below groin and above knee.

thesia or those performed by Bier's venous anesthesia; it can be sterilized, and the troublesome unwinding of a rubber constrictor, with the consequent disturbance and endangerment of the asepsis, is abolished; the blood returns quickly into the bloodless limb, and as the compression can be accurately regulated, the amount of postoperative oozing is greatly diminished and the danger of paralysis abolished.

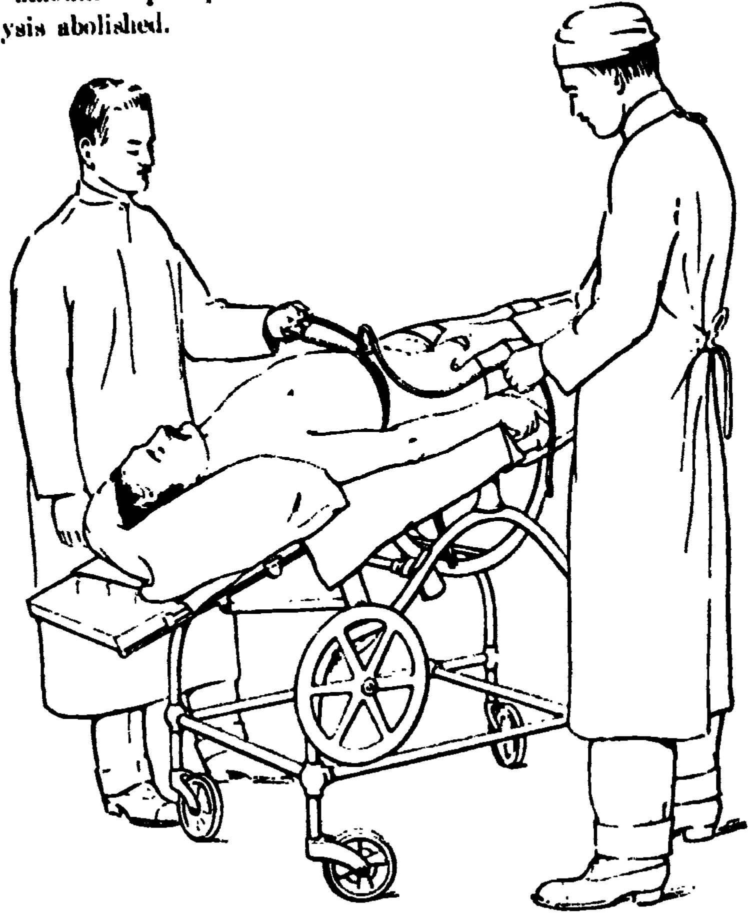


FIG. 38.—MOMBURG'S CONSTRICTION COMPLETED. Testing the femoral pulse.

Momburg's Method of Controlling the Circulation in the Lower Half of the Body.—Grave theoretical objections prevented Esmarch from applying his simple elastic constrictor to the abdomen. It remained for Momburg (1908) to demonstrate that Esmarch's principle could be safely applied. Bier, Axhausen, Gerster and others have reported favorably on this method. Much useful information will be found in v. Sarr's monograph "Über Blutleere der unteren Körperhälfte."

In Momburg's method a soft rubber tube is put under full tension and wound around the waist until the femoral pulse disappears. The tube (Fig. 36) has a cross-section of 10 to 15 mm. and has usually to be wound around from 3 to 5 times.

TECHNIC (Figs. 37, 38).—On account of the severe pain an anesthetic is required. Empty the bowels; examine for deformities of the spine, ptosis of the kidneys, liver or spleen; note the blood pressure. Place the patient in the Trendelenburg position, stand on his right side, pass the end of the tube under the waist to the assistant opposite, stretch the tube to its full extent, and slowly wind it around the waist until it can be seized by the assistant's free hand; then shove the free end under the waist from left to right. This procedure is repeated until the femoral pulse disappears, then the ends are secured with a strong clamp. Secondary rubber constrictors are applied to both thighs just below Poupart's ligament, and to both legs below the popliteal spaces. On completion of the operation the abdominal constrictor is loosened, and the secondary constrictors of the leg freed one by one. In this way the return circulation is gradually switched in, the object in view being to avoid a too sudden strain on the heart.

INDICATIONS.—The employment of Momburg's tube is an exceptional procedure and must be used only in those cases where the loss of blood is of vital importance and where this loss could not be controlled by any other means. It finds its greatest usefulness in extensive resections of the hip, amputations of the pelvis and in interilio-abdominal disarticulations.

CONTRA-INDICATIONS. Deformities of the spine; ptosis of kidneys, liver and spleen; arterial and cardiac disease.

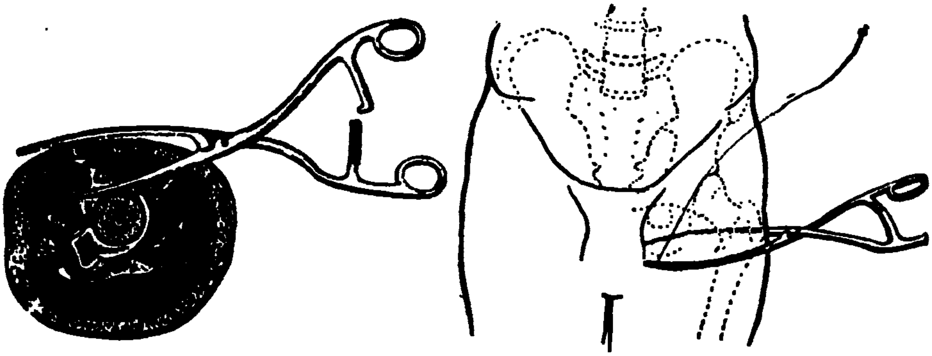


FIG. 39.—APPLICATION OF LYNN-THOMAS FORCEPS-TOURNIQUET.

COMPLICATIONS.—The following have been recorded: Sudden death from acute dilatation of the heart, anuria, transient suppression of the urine, damage of the bowels resulting in mucous diarrhea and hemorrhage.

Lynn-Thomas Forceps-tourniquet (Fig. 39. See also page 361).—These forceps are the most practical of the numerous mechanical devices that have been invented to control hemorrhage in disarticulation of the hip and shoulder. They consist of 2 parallel blades, divergent handles and a strong pressure catch. The flat upper blade is serrated on its under surface, the lower blade is smooth, rounded and probe-pointed. To apply the forceps, the probe-pointed blade is inserted through a small opening in the skin and pushed across the limb beneath the vessels; the serrated blade is applied to the skin and the handles clamped. The skin, inclosed soft parts and vessels are thus compressed between the blades. These clamps were extensively employed in the Boer War and stood the test of practice.

Digital Compression.- Digital compression is applied to the main vessels at or above the site of amputation. Three methods are in use: the direct, which necessitates a preliminary exposure of the vessels, as for example compression of the common iliac through an abdominal incision; the indirect which aims to compress the vessels against some resistant structure; and the flap grasping method. This last is practically obsolete. Formerly when a flap was cut by transfixion, the assistant slipped his hand beneath the flap containing the main vessels, and compressed them between his thumb and fingers. The employment of digital compression requires a skilled strong-handed assistant who can apply a well-regulated pressure; as it is difficult to maintain an efficient compression for any length of time, the surgeon must amputate rapidly. Rapidity of operating should never jeopardize safety, hence this method has justly fallen into disuse.

Preliminary Hemostasis. Preliminary hemostasis of the main vessels may be permanent or temporary, the former produced by ligature, the latter by a controlled ligature or a padded clamp. The permanent ligature may be applied through a special incision, as the ligation of the external iliac in amputations at the hip; or during an early stage in the operation, as ligation of the femoral vessels in the disarticulation of the hip, by the anterior racket incision. In temporary compression the main vessels are exposed and a tape passed around them (traction on the loop kinks and occludes the lumen) or Crile's adjustable screw clamp may be applied. Both these devices produce a satisfactory hemostasis without producing any damage to the vessels. The disadvantage of the method is obvious, necessitating an extension of the original operation and requiring a separate incision.

Coagulin (Kocher-Fonio).- Troublesome oozing from cut muscles that cannot be checked by application of heat or pressure can be controlled by the use of coagulin. This liquid is prepared from sterilized blood plaques by fractional distillation; it has the power of accelerating and increasing the local coagulability of the blood and of preventing secondary hemorrhages.

TECHNIC.—Sponge the bleeding surface and apply the coagulin with a Record syringe.

INDICATIONS AND CONTRA-INDICATIONS FOR AMPUTATION

Advances in modern technic and wound treatment have greatly diminished the number of amputations required. The hard-and-fast rules of former days have passed and each case is now judged on its merits. In general, an amputation of the limb should never be performed unless the prospect of saving the patient's life is thereby increased.

The following indications of Esmarch, if interpreted with surgical judgment, form an excellent working basis:

1. Extensive comminution of bones, laceration of large blood-vessels and nerves.
2. Laceration of the whole musculature, even if the damage to the bone is slight.
3. Very extensive destruction of the skin, rendering the limb useless, and where skin grafting is impossible.
4. Gangrene of a part of the limb.
5. Malignant tumors, excepting myeloid sarcomata.
6. Severe septic or pyemic infections that cannot be cured without removing the source of the infection.
7. Intractable suppuration which threatens the life of the patient.
8. Amputation by choice, when the patient desires to rid himself of a useless encumbrance; atrophied or paralyzed limb; certain deformities, etc.

In gangrene the level at which the amputation is to be performed will depend on the condition of the circulation. To determine this, Moskowicz of Vienna employs the following test: The limb is elevated for 5 minutes, and an elastic constrictor applied; the limb is then returned to the horizontal position and at the end of 5 minutes the constrictor is removed. If the limb is healthy, the circulation returns as a hyperemic blush, reaching the toes in from 2 to 3 seconds. If gangrene be present, the hyperemic wave passes quickly down to the seat of arterial occlusion, then pauses, leaving a clear line of demarcation. Above, the skin is pinkish red, below, white and bloodless. In a few minutes the skin below the line of demarcation becomes slightly mottled, the hyperemic wave then flows slowly down the limb reaching the foot in from 2 to 3 minutes. Other tests based on the principle of the comparison of reactive hyperemias have been employed. The simplest of these is that of Sandrock: In preparing the patient, the extremity is vigorously rubbed with a mixture of alcohol and ether; this is followed by a reactive hyperemia with a sharply defined line of demarcation. As a control, the opposite leg is rubbed and the amount of reactive hyperemia compared.

The following traumatic conditions requiring amputations of an extremity have been set forth by Estes of South Bethlehem. His wide experience and sound judgment make them valuable:

"Avulsion of a limb, of course, admits of no question. Annular crushes (that is to say, when all the tissues of a limb have been crushed through the whole of a limited transverse section of the limb) require amputation. When the soft tissues under the skin, as well as the bone, have been comminuted by a squeeze or pressure of a car wheel or heavy machinery, even though the skin may not be badly lacerated, an amputation will be required. If the bone or bones of a limb be comminuted beyond a distance of 6 cm. (2.5 inches) and the soft tissues immediately about the limb be badly lacerated, one should amputate. Extensive longitudinal and oblique lacerations admit of conservative treatment as a rule, while circular ones are apt to require amputation. Circular lacerations involving the chief blood vessels and nerves as well as the muscles require amputation. In estimating the condition of an injury, the extensive muscular lacerations should receive less consideration than great injury to an extensive area of skin. Compound fractures which sever a large nerve trunk do not require primary amputation. Conservatism should always be tried. The nerve may be sutured and spliced, if necessary."

"*Compound fractures with injury to one system of blood vessels*, when there are two, do not require primary amputation. When both systems of blood vessels are torn, amputation as a rule is necessary. Anastomoses of blood vessels at the site of a badly mangled limb cannot, as a rule, be successfully done.

"*When fractures are comminuted as well as compound*, injuries to the soft tissues are much more extensive. Areas of thrombosis will be much greater and conservatism be less successful. In any given case, while it is probable that conservative attempts may save a limb but leave it in a useless condition or in a doubtful state, it would be best to amputate, if the amputation would assure a useful stump, unless the injury be high up in the thigh where the mortality rate of amputation is high.

"The individual and his trade or employment should always be taken into consideration in determining whether the probabilities should weigh for or against the amputation. Doubtful conservative attempts in cases of very seriously crushed limbs have a larger percentage of mortality than amputation. This fact should also be taken into consideration. In all cases of doubt, having carefully considered the foregoing facts, one should always delay the amputation. Conservation is always the proper policy when there is a good chance for its success. The first sign of gas bacillus or streptococcal infection in these very doubtful delayed cases should determine an amputation immediately, and the open treatment of the stump afterward.

"*Contra-indications.* Marked psychic, physical or hemorrhagic shock (actual anemia) contra-indicate immediate operation. The degree is best measured by a determination of the blood pressure, **and if the systolic blood pressure be below 80 mm. of mercury,** the operation should be postponed. Psychic shock is more apt to be temporary and can be relieved by judicious handling plus the free use of morphin. Physical shock, on the other hand, is harder to deal with and in the severe cases, nerve blocking will have to be resorted to. Hemorrhagic shock (acute anemia) is the most serious condition and calls for prompt and energetic action. The hemorrhage being stopped, the fluid loss is made up by transfusion, intravenous saline infusion, hypodermoclysis or proctoclysis. The deficiency in the general body can be temporarily increased by auto-infusion; by bandaging, the blood is forced out of the vessels of the extremities back into the trunk. Cerebral anemia is guarded against by the use of the dependent head position. The distressing air hunger is relieved by inhalations of oxygen. We place more reliance on the judicious use of morphin, plus the above physical measures for combating shock, than on the use of cardiac stimulants.

"*Time of Amputation.*—In traumatic cases, given the proper surroundings, amputate as soon as the patient's condition warrants it."

MORTALITY

A satisfactory study of the mortality is at the present time rendered impossible by the lack of suitable statistics. The diversity of conditions and associated circumstances under which amputations are performed makes the task extremely difficult and of problematic value. In traumatic cases, given ordinary conditions, amputations of the upper extremities, with the exception of those at the shoulder joint, should give no mortality. The same holds for amputations below the lower third of the leg. Knee joint amputations give a low mortality. Above the knee the mortality rapidly increases. The most important factors in lowering the mortality of amputations are the saving of the blood; the maintenance of asepsis; and choosing the right time to operate. Much valuable information on this subject will be found in Estes' article.

TREATMENT OF DISEASES OF THE STUMP

In considering the diseases of the stump it is necessary to differentiate between the new processes and the continuation or recurrence of the original disease. Beside the pathological possibilities of infection, etc., common to all extensive wounds, the stump may be rendered useless by its sensitiveness or it may develop all the bad features resulting from a conical stump.

Sensitive Stumps.—Sensitive stumps are caused chiefly by exostoses and atrophy. It is safe to say these 2 causes form 80 per cent. of the painful stumps. In the remaining 20 per cent. we will find the causes to be progressive osteitis or periostitis; neuritis from the compression of nerves in the scar tissue; adherent cicatrix with defective nutrition. These last causes were formerly considered to play the most important rôle, but the studies of Bier, Bunge and Hirsch have

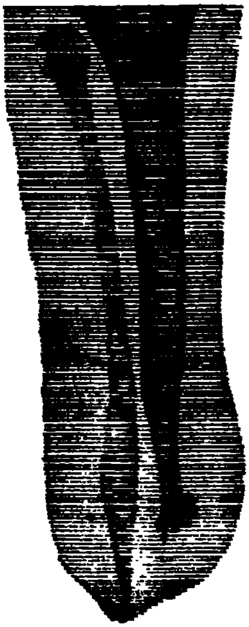


FIG. 40A.—CONICAL STUMP AFTER A SUBPERIOSTEAL AMPUTATION OF THE LEG. (Case of A. Moschcowitz.)

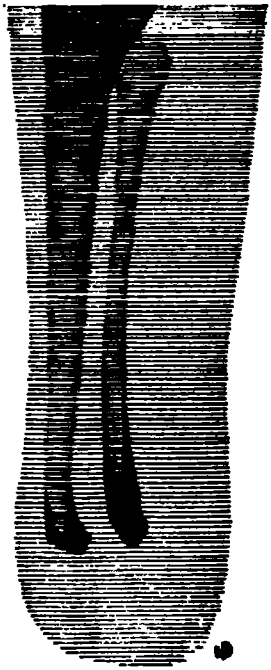


FIG. 40B.—SAME CONICAL STUMP TREATED BY THE OSTEOPLASTIC METHOD. (Case of A. Moschcowitz.)

conclusively proved that these latter features play but a minor part. In the treatment of sensitive stumps, exostoses are prevented by employing the aperiosteal or osteoplastic methods; atrophy, by suitable weight-bearing exercises and early functional use of the stump; neuritis, by dissecting out the compressed nerve and treating the bulbous extremity according to the Ritter or Bier methods (see page 272).

Conical Stumps.—In a conical stump (Fig. 40) the skin and soft parts have retracted, leaving an undue projection of the bone. The apex of the stump is formed by bone covered with a tissue paper cicatrix. This cicatrix not infrequently is the site of a low-grade ulceration, and at times the bone undergoing necrosis projects beyond the skin. The causes of the conical stump are: too short flaps; too low division of the bone; loss of skin and soft parts due to infection and sloughing; retraction of the muscle after a satisfactory primary operation has been performed. In growing children, in amputations through the upper arm and leg, late conical stumps may develop due to an excessive bone growth. To prevent the development of a juvenile stump in the primary operation, the bone should be treated by the aperiosteal or osteoplastic methods, especial care being taken to provide new insertions for the severed muscles, and exercises should be instituted as early as possible to prevent atrophy. The kineplastic amputations of Vanghetti, which aim to preserve the voluntary muscular contractions, would seem to be the best primary operation for children. The treatment of a conical stump consists in a reamputation by the aperiosteal or osteoplastic methods, followed by suitable atrophy-preventing measures.

UPPER EXTREMITY

The fundamental underlying principles of amputations of the upper extremity are the preservation of as much as possible of the limb and the conservation of the movements of the retained part. Weight-bearing plays a secondary rôle.

AMPUTATIONS OF FINGERS

General Considerations.—Always retain a stump, no matter how short, provided the tendons are attached and a suitable skin covering can be obtained. A single finger or stump of finger capable of some function is better than the best artificial hand. In amputations undertaken for disease a set operation can be employed; in traumatic cases the primary considerations are to save as much of the finger as possible and to secure asepsis. Any available skin can be used for the covering. An amputation through the phalanx is preferred to a disarticulation, provided the attachments of the tendons are preserved. The attachment of the flexor profundus is saved by retaining the base of the terminal phalanx; that of the flexor sublimis, by retaining the base of the second phalanx. If the divided ends of the flexor and extensor tendons are sutured, the

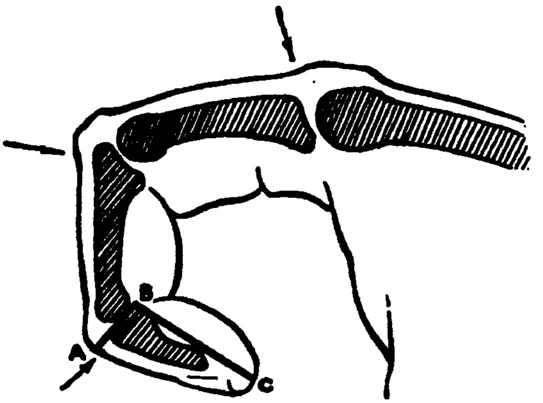


FIG. 41.—RELATION OF THE INTERPHALANGEAL JOINTS AND THE METACARPOPHALANGEAL TO THE KNUCKLES. Disarticulation of the terminal phalanx by a long plantar flap.

patient can control the stump. The fibrous sheaths of the tendons should be closed, so that if infection does occur, its extension will be prevented. The knuckle corresponds to the head of the proximal bone; hence the joint line is always situated below the knuckle (Fig. 41). In disarticulation, the fibrocartilaginous plate, which has its chief attachment to the base of the distal phalanx, should be preserved. The sacrifice of the head of a metacarpal greatly weakens the hand. If, for symmetry, an oblique section is made (Adelmann's operation), the cut surface is to be treated by the aperiosteal or tendinoplastic methods, otherwise a weak, painful hand will result (Fig. 42). Palmar flaps are to be preferred, so designed that the cicatrix will lie on the dorsum. A scar adherent to the end of the stump may render the whole hand useless.

TREATMENT OF THE BONE.—The tendinoplastic and aperiosteal methods are the methods of choice, though good results can also be obtained by the osteoplastic (Fig. 43). The osteoplastic method should never be used in traumatic cases.

AFTER-TREATMENT.—Suitable after-treatment and exercises are just as important in the hand as they are in the lower extremity, and must never be omitted.

AMPUTATION THROUGH THE DISTAL PHALANX

The indications for this amputation are limited to those traumatic cases in which a simple trimming of the bone suffices to produce a useful stump. See also Plastic Flaps on the Finger, page 292.

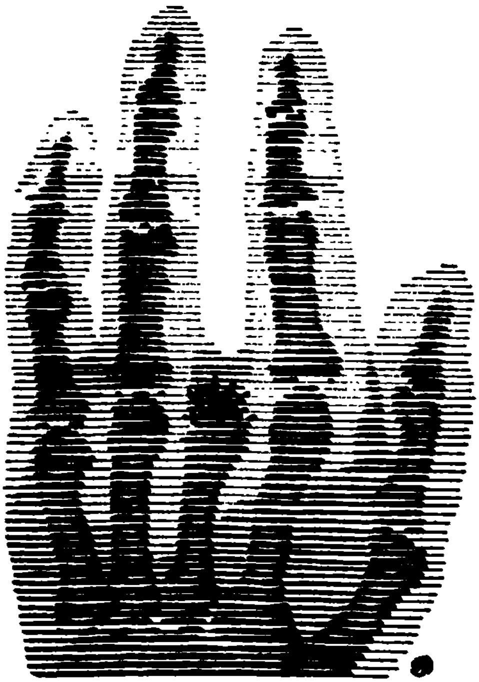


FIG. 42.—RESULT AFTER ADELMANN'S OPERATION. Note spicules. (Ritter.)

Disarticulation of the Distal Phalanx

This is to be preferred to an amputation through the bone, provided the attachments of the flexor and extensor tendons are preserved.

Technic.—Disarticulation is best performed by means of a single palmar

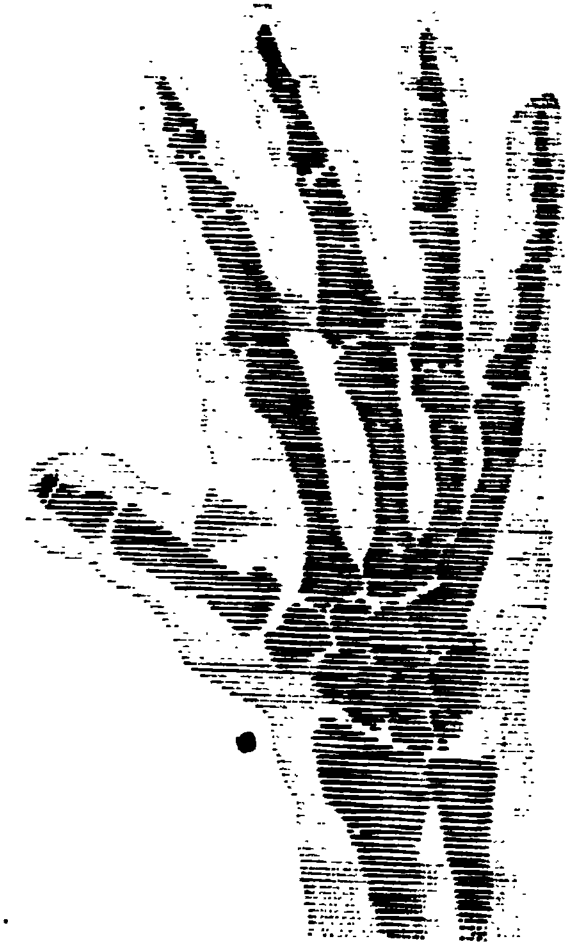


Fig. 43.—Painful Thumb Following a Subperiosteal Amputation. Cured by a bone plastic. (Case of A. Moschcowitz.)

flap. Choose a narrow-bladed "finger-knife," grasp the digit between the left forefinger and thumb, ascertain the position of the joint (Fig. 41), flex to right angles and mark out the flap ABC (Figs. 41, 44). Holding the knife at right angles to the skin, cut into the joint by means of the dorsal incision AB. This incision divides the extensor tendon. Divide the lateral ligaments, press the base of the phalanx forward, divide the glenoid ligaments and the insertion of the flexor digitorum profundus. Hugging the bone, carry the knife around the base of the phalanx, then forward, parallel to its palmar surface. Suture the flexor and extensor tendons over the head of the second phalanx or to the glenoid ligament. Attend to the hemostasis. Close the wound with 3 to 4 interrupted silk sutures. Drainage is unnecessary. Bring the dressing around the stump from the palmar to the dorsal surface. Immobilize in a light splint which fixes the adjacent fingers and wrist. Keep in moderate elevation.

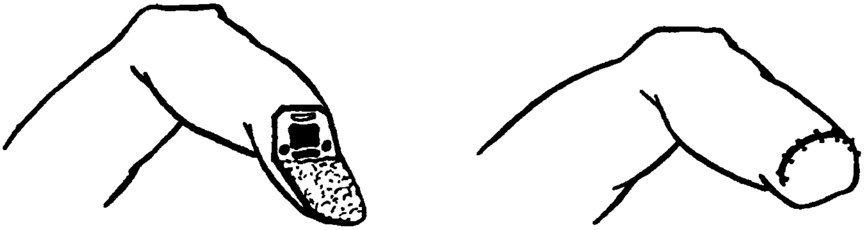


Fig. 44.—Disarticulation of the Terminal Phalanx by a Palmar Flap.

After-treatment.—This consists in massage movements and pressure exercises.

Comment.—This method yields a serviceable tactile stump, with the scar placed well back on the dorsum. A similar result can also be obtained by using the oblique circular method.

Amputations of the First and Second Phalanges

In the second phalanx an amputation is to be preferred to a disarticulation, provided the attachment of the flexor sublimis to the head of the second phalanx can be preserved or its function maintained by a reinsertion. If those conditions cannot be fulfilled, the finger must be disarticulated at the first interphalangeal joint, or amputated through the proximal phalanx.

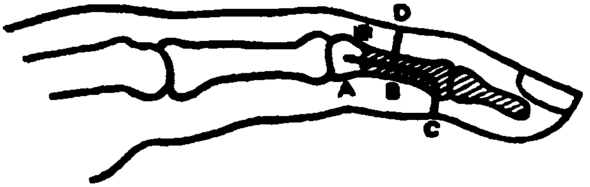


Fig. 45.—Amputation of the Second Phalanx.

Technic.—UNEQUAL DORSAL AND PALMAR FLAPS.- The length of the palmar flap in an amputation should equal the length of the diameter of the finger at the point of bone section; in a disarticulation it should slightly exceed this. The dorsal flap is ⅓ the length of the palmar. Select the site of bone section (X). With the finger held in pronation, outline the flaps ABC, ABD (Fig. 45). The wounding of the digital artery is to be avoided, and an adequate blood supply provided for the palmar flap by placing the lateral incision midway between the dorsal and palmar surfaces. Deepen the lateral cuts to the bone, dissect up the dorsal flap, include in it all tissues down to the bone, secure the extensor tendon and prevent it from retracting. Dissect up the palmar flap, secure the flexor tendon at the distal end of the flap and prevent its retraction. Retract the soft parts and divide the bone with a fine saw. Treat the bone stump by the tendinoplastic method, suturing the tendons over the bone surface. The tendons are put slightly on the stretch in order to maintain their function. If the tendinous material is insufficient to properly carry out the tendinoplastic method, treat the bone by the aperiosteal method and provide a more proximal insertion for the tendons. Close the wound with interrupted silk sutures. The scar is a transverse dorsal one and lies just below the bone.

THE SINGLE LONG PALMAR FLAP. The flap must be equal to 1½ times the diameter of the digit at the point of bone section. The long palmar flap can be used for amputations through the first interphalangeal joint. It is the method of choice in the terminal phalanx, but is not so applicable in the first and second phalanges as the length of flap required entails a needless sacrifice of skin and a corresponding interference with the nutrition of the flap.

Disarticulation can be carried out by either of the above methods, but due allowance must be made for the expanded head of the phalanx and the palmar flaps must be cut larger.

Comment.—The operation may be performed by the oblique circular incision. Equal anteroposterior or lateral flaps give unsatisfactory terminal scars, which are subjected to pressure. Amputations by large terminal or external flaps possess the same defect, but to a lesser degree.

PLASTIC OPERATION ON THE FINGER TIPS

When the tip of the finger is lost and a satisfactory covering cannot be obtained, it is usual to sacrifice a portion of the phalanx. In certain occupations, piano playing, etc., such a diminution in the length of the digit entails a serious impairment of its functional value. The following plastic procedures have been employed to avoid such a loss: (1) skin grafting; (2) transference of flaps from other parts of the body; (3) plastic flaps from the finger itself; (4) transplantation of another finger tip or toe.

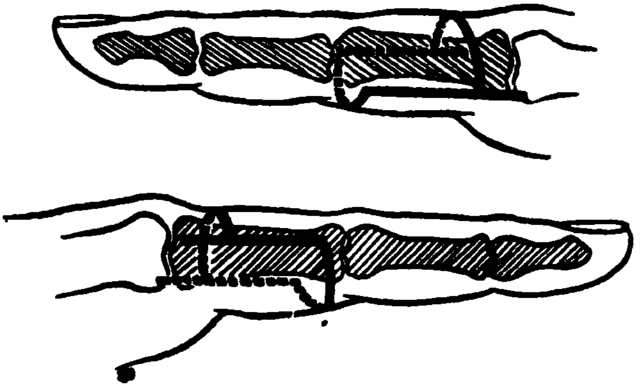


FIG. 46.—DISARTICULATION AT THE METACARPOPHALANGEAL JOINT BY A LONG PALMAR AND A SHORT DORSAL FLAP.

Skin Grafting.—Small bony defects may be covered by skin grafts. The Thiersch method does not give very satisfactory results. Wolf's grafts are more serviceable.

Transference of Flaps from Other Parts of the Body.—Suitable "muff grafts" can be obtained from the chest, abdomen, etc. Sensation slowly appears in these flaps. After they have been transferred to the hand and have become well nourished, they can be employed to form secondary flaps. For instance, the flaps used in the making of a new thumb (Fig. 59) were cut from a flap which was originally obtained from the abdomen.

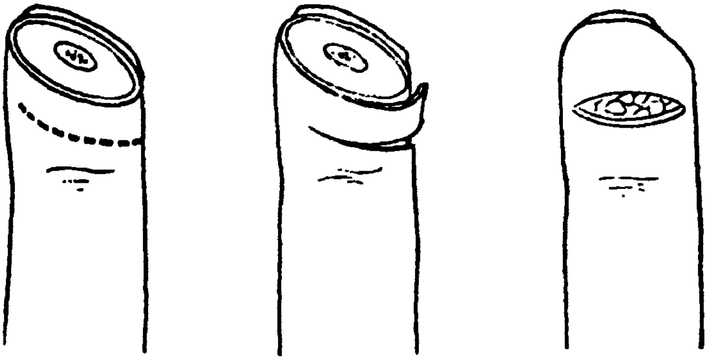


FIG. 47.—OBLIQUE TRAUMATIC AMPUTATION OF FINGER WITH METHOD OF COVERING TIP.

Plastic Flaps from the Finger Itself. Klapp, in certain traumatic cases, where it was desirable to preserve the longest possible stump, has employed skin flaps from the palmar aspect of the finger to cover the bone. By a single or a bridge flap he has been able to produce serviceable pressure-bearing tips. Where the finger is cut off obliquely through the nail (Fig. 47), a single flap with a lateral attachment is made, carried over the bone, and its free end sutured at the opposite side of the finger. The resulting defect is left to granulate, or it can be covered with a skin graft. Where the finger is cut off transversely (Fig. 48), make an incision on the palmar surface at a short distance above the wound, and form a bridge flap. Draw this bridge over the end of the bone and suture in place. The resulting defect is allowed to granulate or it is covered with a skin graft.

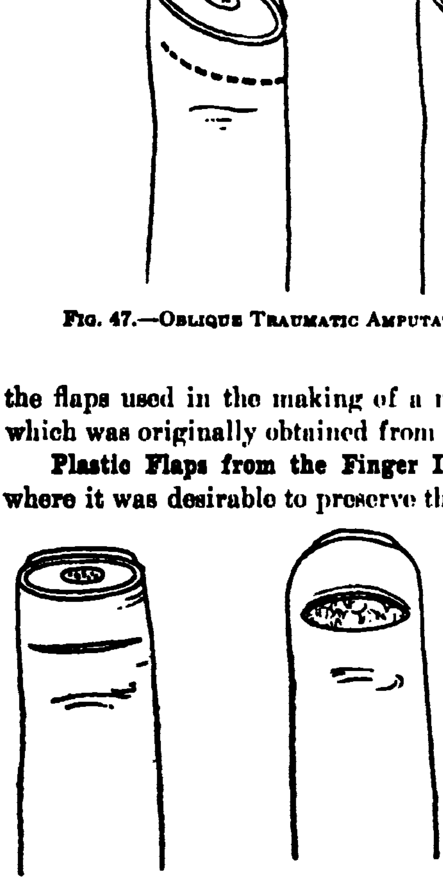


FIG. 48.—TRANSVERSE TRAUMATIC AMPUTATION OF THE FINGER TIP WITH METHOD OF COVERING DEFECT.

COMMENT.—We have found these simple procedures very satisfactory.

Transplantation of a Finger Tip from Another Finger or Toe.—Nicoladoni successfully covered a finger tip by transplanting a finger tip from another digit that had to be sacrificed. The method employed is shown in Figure 49. If required, a similar covering could be obtained from the toe.

DISARTICULATION AT THE METACARPOPHALANGEAL JOINTS

Surgical Anatomy.—In the disarticulations of the middle and ring fingers the heads of the adjacent metacarpals protect the terminal cicatrix from pressure; while in the thumb, index and little fingers, this protection to the terminal cicatrix is lacking. The joint line lies $\frac{1}{3}$ in. below the prominence of the knuckle. The relatively larger size of the head of the metacarpal must be kept in mind so that sufficient covering may be provided. The strength of the palm of the hand is directly dependent on the integrity of the normal relationship of the heads of the metacarpals; and any removal of a metacarpal, or even a portion of the head, is bound to break the arch and greatly weaken the hand. In the thumb, the short flexor, the short extensor, the short abductor and the adductor are inserted into the base of the first phalanx.

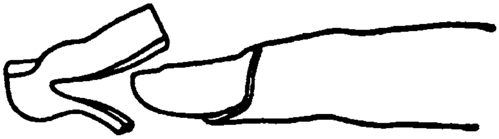


FIG. 49.—FINGER TIP PLASTIC. The tip taken from a finger that could not be saved. (Nieuladoni.)

Technic. For disarticulation of the middle and ring fingers, racket or lanceolate incisions are used; for the thumb, index and little fingers, Farabeuf's method of lateral palmar flaps.

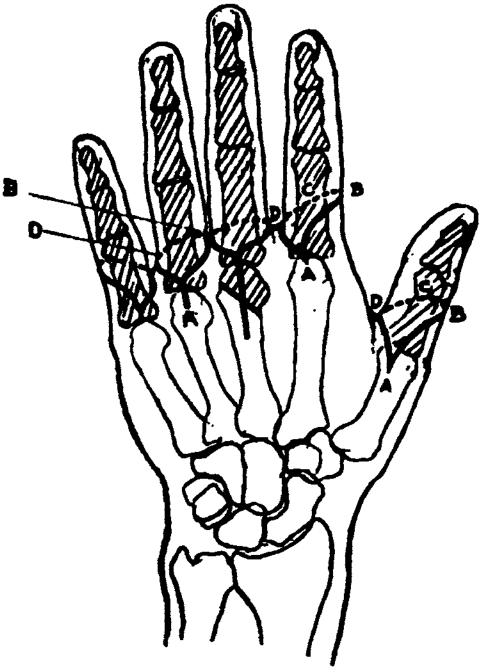


FIG. 50.—DISARTICULATION OF THE FINGERS.

DISARTICULATION OF RING FINGER AT THE METACARPOPHALANGEAL JOINT (Fig. 50). Locate the joint line. With the left hand grasp the finger to be removed and have the assistant hold the remaining fingers away with a bandage retractor. Outline the flap ABD. The transverse portion follows exactly in line with the web of the fingers (if it is carried up on the palm, an ugly projection of skin will result). Place the handle of the racket over the center of the bone.

DISARTICULATION OF MIDDLE FINGER AT THE METACARPOPHALANGEAL JOINT (Fig. 51).—Hyperextend the finger, deepen the palmar incision to the bone, divide the flexor tendons, turn the finger from side to side and carry the lateral incision to the bone. Divide the tendons while the finger is in mid-position, open the joint from the palmar aspect, cut the attachment of the glenoid ligament, divide the lateral ligaments and complete the disarticulation by severing the extensor tendons. Suture the opposing tendons to the capsule or to one another. Ligate the palmar digital arteries and close the wound with interrupted silk sutures. If there is a projection of skin on the palmar surface, remove a small V-shaped piece. Dress and immobilize the hand and wrist in a light splint.

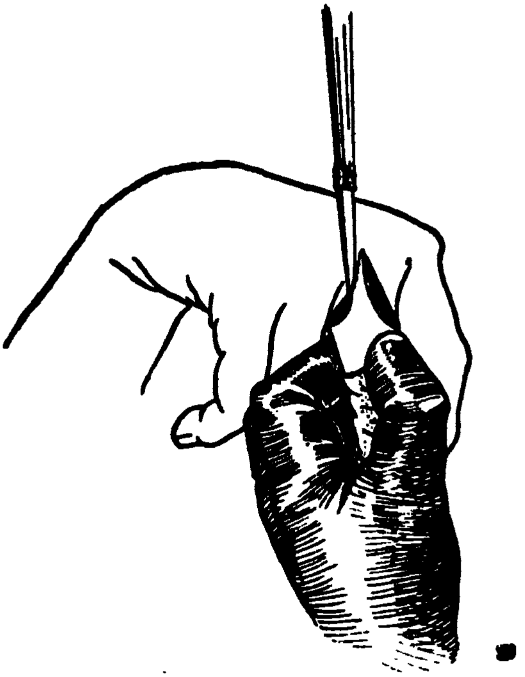


FIG. 51.—DISARTICULATION OF THE MIDDLE FINGER AT THE METACARPOPHALANGEAL BY A DORSAL RACKET INCISION.

DISARTICULATION OF THE THUMB AT THE METACARPOPHALANGEAL JOINT (Fig. 50).—The thumb is the most important digit of the hand. As its functional value exceeds that of the other 4 fingers, it is essential to save as much of this important member as possible. Therefore, an amputation through the proximal phalanx is always preferred to a metacarpophalangeal disarticulation. This latter procedure is never an operation of choice, but is to be confined to the cases in which the sacrifice of the proximal phalanx is an absolute necessity. A short or an ugly stump may be of great value to the hand; while a shapely one, if tender, is a veritable curse.

The best method of disarticulation of the thumb at the metacarpophalangeal joint is by the externopalmar flap of Farabeuf. Other methods are the racket and the oblique palmar flap.

DISARTICULATION OF THE THUMB BY THE EXTERNOPALMAR FLAP.—Locate the joint line, mark out the flap ABCD. The point A is situated on the dorsal aspect of the joint line, just external to the long extensor. The point B lies 1.5 cm. above the joint line and represents the junction of the palmar and external surfaces; the point D corresponds to the junction of the web with the thumb. The incision ABCD marks out a convex flap with a breadth equal to ½ the circumference of the thumb and a length of 2.5 cm. (1 in.); the second incision AD traverses the dorsal-internal surface and represents the shortest distance between the terminations of the first incision. Dissect up the flap to the base, cut the flexor tendons, prevent their retraction, cut the extensors above the joint line, enter the joint from the dorsal and internal

aspect, retain the sesamoid bones and the glenoid ligament, close the tendon sheaths and suture the opposing tendons over the bone or provide new insertions. Attend to the hemostasis and close the wound with interrupted silk sutures. The resulting cicatrix falls on the dorsum, between the metacarpal bones.

DISARTICULATION OF THE THUMB BY THE RACKET INCISION. The technic of this operation is the same as that for the ring and middle fingers, with the important exception that the handle of the racket, instead of being over the middle of the bone, is placed somewhat nearer the midline of the hand, the object being to protect the resulting cicatrix from pressure.

DISARTICULATION OF THE THUMB BY THE OBLIQUE PALMAR FLAP.—This method is wasteful of tissue and possesses no advantages over the externopalmar or racket methods.

COMMENT.—Whatever method is employed, the mobility of the metacarpus of the thumb makes it essential that the tendons controlling its movements are accurately sutured; otherwise, unnecessary loss of function and retraction deformity will result. For instance, if the long extensors and the short abductors are not secured, the short flexors of the thumb will be unopposed. The externopalmar flap method is economical of tissue, provides a suitable flap for the head of the metacarpus, an easy access to the joint and a good functional stump with a cicatrix protected from terminal and lateral pressure.

AUTOPLASTIC TRANSPLANTATION FOR TRAUMATIC OR OPERATIVE LOSS OF THE THUMB AND INDEX FINGER. Nicoladoni in 1898 replaced a thumb by transplanting the second toe. This was done in 2 sittings and the function of the tendons was retained. Von Eiselsberg replaced the distal half of the index finger. Krause, Klimm and others have successfully employed this method, modifying it to suit the conditions present. The 2 accompanying figures (Figs. 52, 53) illustrate the manner of performing this operation. As it involves the principles underlying joint transplantation, the reader is referred to the original articles of Nicoladoni, Von Eiselsberg, Klimm and Krause.

DISARTICULATION OF THE INDEX FINGER AT THE METACARPOPHALANGEAL JOINT (Fig. 50).—The best method is by the externopalmar flap of Farabeuf. The flap, which is cut from the external and palmar surfaces, readily covers the head of the metacarpus, gives an easy access to the joint, and yields a good stump with a dorsal cicatrix well out of the way of pressure.

TECHNIC.—Locate the joint line, outline the flap ABCD. The point A is on the dorsal point line, just external to the extensor tendon; the point B lies 1.5 cm. above the joint line and represents the junction of the external and palmar surfaces; the point D is the junction of the interdigital web with the index finger, which on the palm corresponds to the internal end of the digitopalmar fold. The incision ABCD marks out a convex flap equal to ½ the cir-

cumference of the digit. The convex incision passes downward, gradually working outward across the dorso-external surface; at the junction of the palmar surfaces (B) lying 1 cm. (2/5 in.) above the digitopalmar crease, while on the palmar surface it passes upward and inward to the inner extremity of this crease (D). The second incision DA joins the end of the first incision. It crosses the dorso-internal surface and represents the shortest distance between the points A and D. The flap is raised to its base, the extensor tendon cut at the level of the joint, and the joint entered from the dorso-internal direction. The remaining steps are carried out as in disarticulations of the ring and middle fingers.

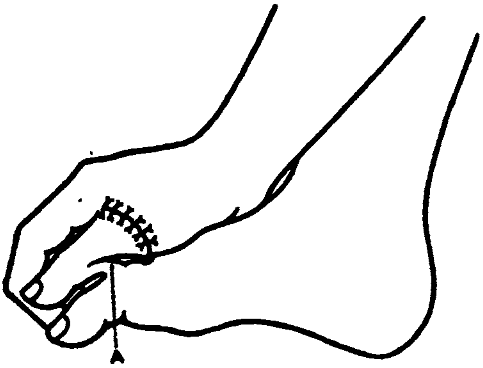


Fig. 52.—Grafting of the Second Toe to Replace the Amputated Thumb. (Nicoladoni.)

DISARTICULATION OF THE LITTLE FINGER AT THE METACARPOPHALANGEAL JOINT (Fig. 50).—The same method is employed in the little finger as is used for the thumb and index fingers, the only difference being that the flap, instead of being fashioned from the palmar and external surface, is cut from the palmar and internal surface.

Comment.—As the strength of the palm depends on the integrity of the relationship of the metacarpals, it is essential to preserve the heads in all the metacarpophalangeal amputations. The sacrifice of such an important keystone is hardly justified by the excuse that the soft parts are scanty, as a flap can be readily obtained from the chest or abdomen. To sacrifice it for the sake of improving the symmetry of the hand is a serious error. A primary comparison of the symmetry of 2 such hands will be in favor of the hand in which the head has been excised. If the same comparison is made 6 to 8 months later, it will be noticed that the atrophy of the bone and surrounding parts will have greatly diminished the gap between the fingers and that the symmetry of the hand compares favorably with the unduly narrowed hand (Figs. 42, 54). The functional comparison is all in favor of the hand in which the head is retained. The excision of the head, besides resulting in a weak hand, often leaves a tender palm which renders the hand useless.

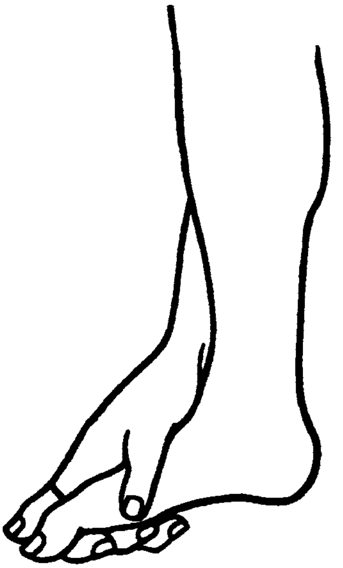


Fig. 53.—The Substitution of the Second Toe for a Missing Index Finger. (Nicoladoni.)

AMPUTATIONS OF THE FINGERS AND THUMB TOGETHER WITH PORTIONS OF THE METACARPALS

Traumatic or diseased conditions necessitating the removal of a metacarpal are rare. The general rule is to preserve as much of the metacarpal as possible, a partial removal being preferred to a disarticulation. The following procedures will be described:

(1) Partial amputation.
(2) Disarticulation of a finger with the corresponding metacarpal.
(3) Disarticulation of thumb with its metacarpal.
(4) Amputation of two or more fingers with their metacarpals.

Partial Amputation.—The general plan of the operation is the same as that for complete amputation. In this operation an endeavor is made to save as much of the bone as possible, to preserve the attachment of the essential tendons and to treat the bone stump by the aperiosteal or tendinoplastic methods. The risk of wounding the deep palmar arch in this operation is very slight. The carpometacarpal synovial sacs are not opened and if the bone be divided distal to the center, the synovial sheaths of the three middle fingers can be avoided. The best method is by the racket incision. The body of the racket follows the line of the web to the fingers and corresponds on the palmar surface to the digitopalmar crease; the handle of the racket is placed over the center of the dorsum of the bone, and commences a little above the point of the bone section. In the thumb the handle should not be placed in the middle, but more internally, that is, over the interosseous space; in the little finger it should be placed a little externally. The bone is sawn to prevent splintering. Beveling of the second and fifth metacarpals presents no real advantage and is liable to produce painful stumps (Figs. 42, 55).

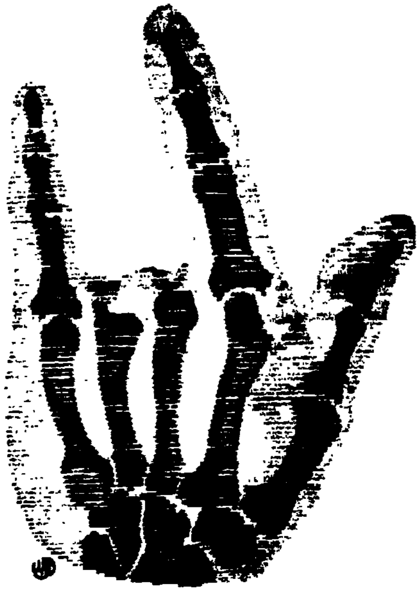


FIG. 54.—RESULT AFTER DISARTICULATION OF THE MIDDLE AND RING FINGERS. Strong useful hand. Contrast with Figure. 42.

Disarticulation of a Finger with the Corresponding Metacarpal Bone (Fig. 56). —TECHNIC.—Locate the joint line, pronate the hand, grasp the digit and trace out the racket incision ABCDE. The point A is placed on the dorsum a little above the joint line; the point B is placed over the base of the metacarpal; the points E and C represent the junctions of the web with the sides of the fingers; the point D is the center of the digitopalmar crease. Deepen the dorsal incision AB, divide the extensor tendons above the base of the bone, retract the edges of the wound and carefully detach the interossei and divide the interosseous ligaments. Deepen the incision BC and BE, hyperextend the finger and carry the palmar incision EDC down to the flexor tendons, dividing the tendons at the level of the neck. Force the finger backward and expose the palmar surface of the bone as far up as possible. Divide the ligament of the joint and bend the finger back on the dorsum of the hand; in this position the remaining adhesions to the palm can be severed. Close the sheaths of the tendons and reinsert or suture together the flexor and extensor tendons. A transverse incision over the carpometacarpal joint may be required to give the proper exposure of the joint. In the index finger the handle of the racket should not be over the center of the shaft but a little to its inner side, while in the little finger the handle should be placed slightly to the outer side of the shaft. In disarticulating the fifth finger the hypothenar muscles must be kept intact.

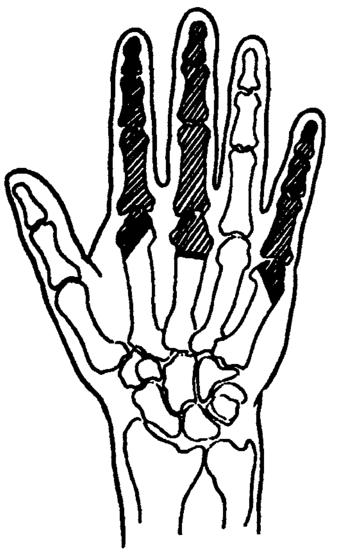


FIG. 55.—AMPUTATION THROUGH THE METACARPAL OF THE FINGER WITH BEVELING OF THE BONE. (Adelmann Op.)

Disarticulation of the Thumb with Its Metacarpal Bone (Fig. 56).—This operation should never be performed unless absolutely necessary, as a useful new thumb can be made from the metacarpus (see Huguier's Operation, page 300). Two points must be kept in mind: first, the danger of wounding the radial artery as it passes between the first and second metacarpals at the upper end of the interosseous space; second, the muscles of the thenar eminence must be preserved intact.

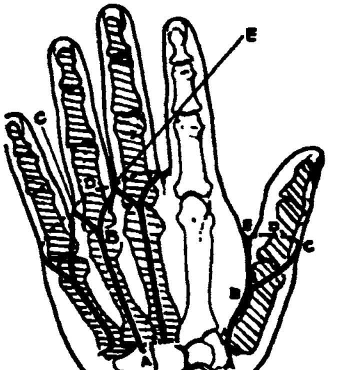


FIG. 56. — DISARTICULATION OF THE FINGERS. Disarticulation of the ring, middle and little fingers at their carpometacarpal joints by the mid-dorsal racket incision. Disarticulation of the thumb at the carpometacarpal joint by a dorso-internal racket incision.

TECHNIC.—The oblique racket is the best incision. Locate the joint line, mid-pronate the hand, and trace out the racket incision ABCDE. The point B lies a little above the joint line and slightly to the inner side of the shaft; the point A at the inner end of the carpometacarpal joint; the handle of the racket AB lies over the interosseous space just internal to the shaft; the point E corresponds to the junction of the web with the thumb; the point C lies at the junction of the palmar and external surfaces; the point D lies on the palmar just above the joint level. The line BE follows the opposition crease of the thumb;

the line BC is placed a little nearer the nail than BE. Deepen the incision throughout, severing the extensors in the transverse portion of the wound.

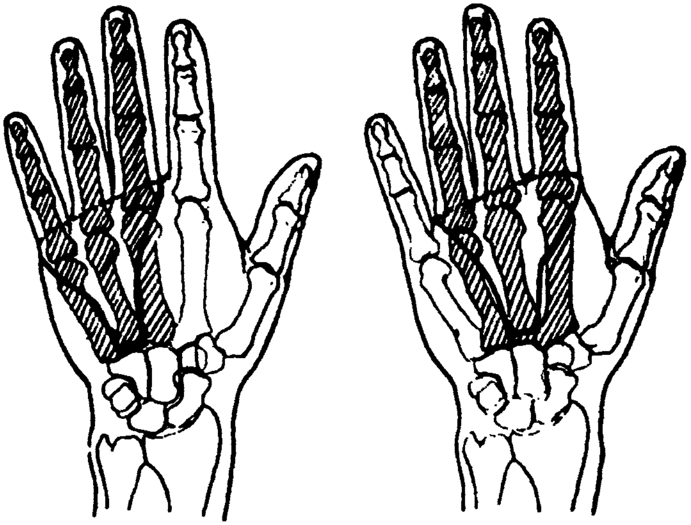


FIG. 57.—AMPUTATION OF INDEX, MIDDLE AND RING FINGERS WITH THEIR CORRESPONDING METACARPALS.

Through the dorsal incision, carefully separate the muscles from the metacarpal, hyperextend the thumb, cut the long flexors on a level with the palmar incision, locate the carpometacarpal joint, open it on the dorsal and external aspect, cut the ligaments and throw the head outward and backward. By a series of short nicks applied against the palmar surface of the bone, shell it out of its bed. Unite the opposing tendons and close the wound with interrupted silk sutures.

COMMENT.—This operation does not give as good a functional result as a disarticulation at the metacarpophalangeal joint plus the freeing of the metacarpal, the procedure in Huguier's operation. This latter yields a short but useful thumb (see page 300).

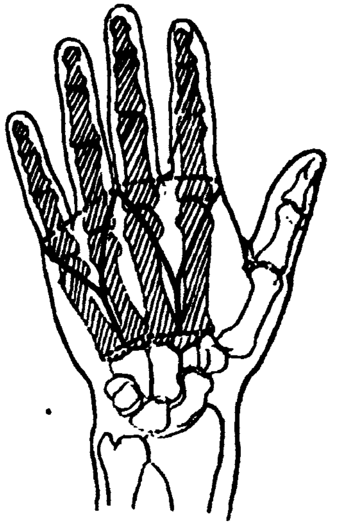


FIG. 58.—DISARTICULATION OF THE RING AND LITTLE FINGERS, AND OF THE INDEX AND MIDDLE FINGER WITH THE CORRESPONDING METACARPALS.

Amputations of Fingers with Metacarpal Bones.—These operations are rarely employed for disease, and it is useless to attempt to classify or describe the diverse operations that may be employed in the traumatic cases. In removing the diseased or crushed metacarpals, the governing principles are the economizing of tissue, the conservation as far as possible of the movements of the parts retained, and the attaining of an aseptic wound.

The accompanying diagrams (Figs. 57, 58), indicating the flaps to be used, are offered as suggestions.

The Formation of a New Thumb from the Metacarpus (Huguier's Operation, Fig. 59).—This operation was performed by Huguier of Paris in 1852. His method and results were published in 1873 and 1874 under the title of "Anatomical and Physiological Considerations on the Actions of the Thumb and on the Surgery of this Organ" (46). Klapp, 1912, described a similar procedure and gave an illustration showing the new thumb grasping the handle of a mallet. Figure 59 illustrates a personal case, in which a useful thumb was formed from the metacarpal. In this case the skin of the dorsum of the hand, with the exception of that of the little finger, was destroyed, and a new covering had to be obtained from the abdomen by means of a muff graft; when the nutrition of the transplanted skin became satisfactory, flaps for the new thumb were formed from this skin. The metacarpal of the thumb differs from those of the rest of the hand in being movable in action; and from a functional standpoint it can be considered as the first phalanx of the thumb. Huguier, recognizing the function of the first metacarpal, rendered its inferior half free by enlarging the interosseous space. The freed head of the metacarpal fulfills one of the functions of the thumb, as it is able to grasp and hold objects between its head and the second metacarpal.

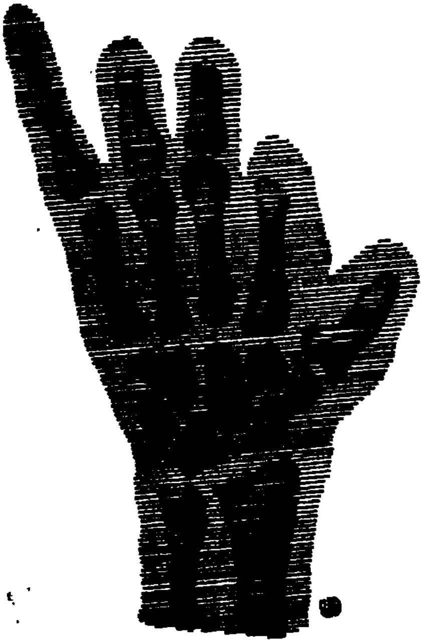


FIG. 59.—FORMATION OF A NEW THUMB FROM THE METACARPUS. Result obtained after a traumatic amputation. (Hugier Op.)

INDICATIONS.—Traumatic loss of the thumb and diseases of the thumb necessitating its sacrifice at the metacarpophalangeal joint. In diseased conditions it may be performed as a primary operation, in traumatic cases it will find its greatest usefulness after cicatrization has taken place. If sufficient skin cannot be obtained from the hand to make the flaps, it can be transferred from other portions of the body.

TECHNIC.—With the hand prone make a dorsal incision, midway between the first and second metacarpals, the upper extremity corresponding to the middle of the high portion of the interosseous space. This dorsal incision exposes the external border and base of the first dorsal interosseous and the dorsal aspect of the metacarpals. Divide the interosseous where it is attached to the bone; if present expose the tendon of the adductor of the thumb, detach it from its insertion on the first phalanx and reimplant. Suture the skin edges from before backward, placing 1 suture at the apex, 3 on the thumb side and 3 on the index. The operation yields a short but useful stump. Klapp employs a palmar as well as a dorsal incision.

COMMENT.—This operation yields a much better functional result than disarticulation at the metacarpophalangeal joint, and should be employed in place of the latter.

DISARTICULATION AT THE WRIST

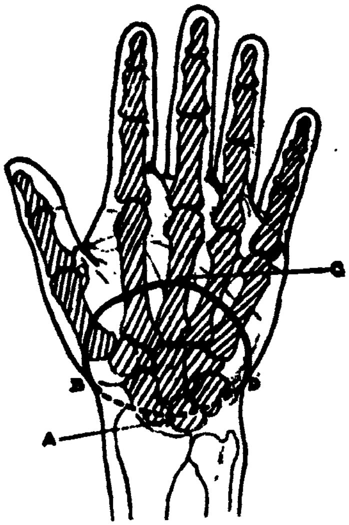


FIG. 60.—DISARTICULATION OF THE HAND AT THE WRIST BY AN OBLIQUE CIRCULAR INCISION.

History.—According to Blasius, Fabricius Hildanus first performed this operation. Amputation by means of an external flap, variously attributed to Poupart, Dubreuil, V. Walther and Guthrie, was described by Soupart in 1847. He also described the internal flap. The circular method was perfected by Brasdor and Sabatier. In the pre-antiseptic days, Petit, Larrey, Cooper and Sédillot considered a disarticulation at the wrist more dangerous than an amputation through the forearm.

Anatomical Points.—The tip of the styloid process of the radius is the best guide to the joint. A line drawn between the two styloid processes marks the extreme limits of the joint. The dome of the joint line lies ½ in. (1.25 cm.) above this line. The wrist joint has a separate synovial sac.

Indications.—Disarticulation should never be performed as long as a movable finger or a portion of the hand can be saved. It is to be preferred to an amputation through the lower third of the forearm, as the inferior radio-ulnar joint and the pronator and supinator muscles are retained. The resulting stump gives a good purchase for an artificial hand, and the preservation of the insertions of supinators and pronators makes it more useful. The methods to be used are largely dependent on the amount of skin available.

Methods of Disarticulation.—The methods of disarticulation are the oblique circular (elliptical), transverse circular, external flap, internal flap, long palmar flap, dorsal flap.

Oblique Circular (Elliptical) Method (Fig. 60).—Trace the incision ABCD. The point A, corresponding to the upper end of the incision, is situated on the dorsum of the wrist over the center of the joint line. The point B is on the radial border of the hand, at a level with the first carpometacarpal joint. The point D lies on the ulnar border between the pisiform and the base of the fifth metacarpal. The diameter BD is equal to the width of the wrist. The point C, representing the lower end of the incision, lies on the palm about 6.25 cm. (2½ in.) below the joint line. Flex the hand strongly, divide the extensor tendons over the dorsum, then cut through the extensors of the thumb, the extensor carpi ulnaris and the lateral ligament below the styloid process. Open the joint, separate the flexor tendons from the carpus, cutting them at the lower level of the flap. Attend to hemostasis. Suture the flexor and extensor tendons over the ends of the stump. Draw the palmar flap upward and backward, and unite with interrupted silkworm-gut sutures. The flap is well nourished, accustomed to pressure and possesses tactile sensation. The cicatrix is dorsal and well protected from pressure.

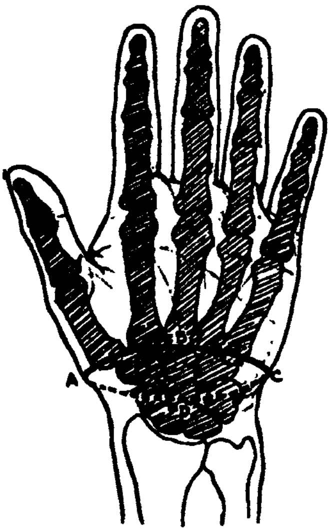


FIG. 61.—DISARTICULATION AT THE WRIST BY A TRANSVERSE CIRCULAR INCISION.

Transverse Circular Method, Brasdor-Sabatier (Fig. 61).—Locate the joint line, trace the circular incision ABCD around the hand from about 5 to 7.5 cm. (2 to 2½ in.) below the joint line, deepen, and allow the skin to retract. Raise the cuff of skin with a few touches of the knife until the styloid processes are exposed. Put the internal lateral ligament on the stretch, divide the extensor carpi ulnaris and the lateral ligament, enter the joint, flex the wrist, cut the extensor tendons and dorsal ligaments, then the external lateral and the flexor tendons. Attend to the hemostasis. Pull the nerve trunks down and cut them short, suture the tendons of the stump in order to preserve the motions of the muscles of the forearm. Close the wound with interrupted silkworm-gut. The scar, though terminal, is partially protected from pressure as it falls between the two styloid processes.

External Lateral or Radial Flap, Guthrie-Soupart-Dubreuil (Fig. 62).—Locate the joint line. Trace the incision ABCD. The dorsal point A represents the junction of the outer and middle thirds of the wrist, and is situated slightly below the joint line. The point B is on the radial side of the thumb over the middle of the first metacarpal. The point C on the palmar surface corresponds to the point A on the dorsum. The point D is on the ulnar border just below the styloid process. Dissect out the flap ABC, including all the muscles of the thenar eminence. Divide the skin and soft parts internal to the flap by the circular incision ADC and disarticulate. The external flap ABC is then sutured transversely across the radius and ulna. Care must be taken to avoid placing the cicatrix over the end of the radius, where it would be subjected to the greatest pressure.

Internal Flap (Fig. 63).—This method, which is a development of the

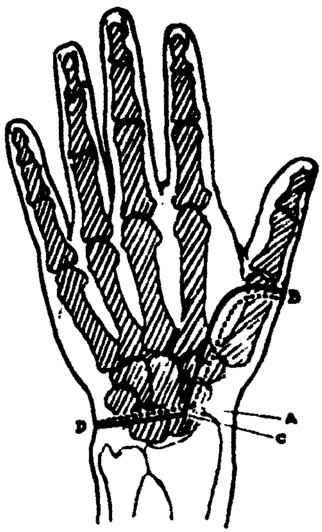


Fig. 62.—Disarticulation of the Hand at the Wrist by an External Flap. (Guthrie-Soupart-Dubreuil Op.)

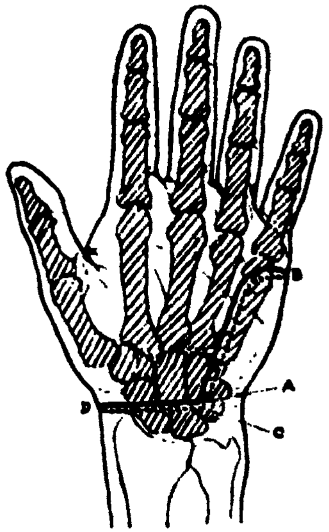


Fig. 63. Disarticulation of the Hand at the Wrist by an Internal Flap.

above operation, is greatly inferior to it, is rarely applicable, and is to be reserved for traumatic cases. In employing this method, sufficient skin must be allowed to cover the radius. It leaves a cicatrix over the radius, and difficulty is sometimes encountered in obtaining a covering for the radius.

Long Palmar Flap (Fig. 64). This method possesses no advantages over the oblique circular. It requires more tissue from the palm, and the thick flap is awkward to handle and difficult to adjust.

Dorsal Flap.—When sufficient palmar tissue cannot be obtained, an oblique circular incision with the flap on the dorsum may be used.

Comment.—The oblique circular method is the best and most universally applicable; the transverse circular is the simplest, but it provides a scanty covering and the cicatrix is liable to be subjected to pressure; the external flap method is reserved for those cases in which the above methods are not applicable; the long palmar flap is more difficult to perform and possesses no advantages over the oblique circular.

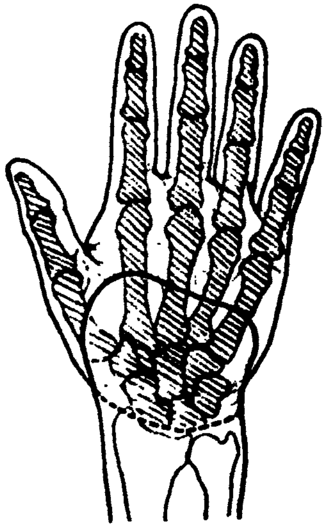


Fig. 64. — Disarticulation of the Hand at the Wrist by a Palmar Flap.

After-treatment of Disarticulation of the Wrist.—Bandage the stump to a light palmar splint, and as soon as the wound is healed, institute a systematic course of massage, muscular movements and pressure exercises. The after-treatment of stumps is just as important in the upper extremity as in the lower, and must never be omitted.

AMPUTATION THROUGH THE FOREARM

Anatomical Points.—The lower third of the arm is cylindrical in shape, the upper two-thirds conical. A section of this latter shows that the transverse diameter exceeds the anteroposterior. The radius and ulna are parallel when the arm is in mid-pronation, farthest apart in full supination and closest in pronation.

General Considerations.—In amputating through the forearm choose the method which yields the longest stump. On account of the conical shape of the stump a prosthetic apparatus cannot be adjusted to the forearm alone, but must also receive support from the elbow. The greater the length of bone retained, the less the danger of the stump slipping out of its socket. Whenever possible, in amputations in the upper forearm, the bony portion of the arm to which brachialis anticus, biceps, anconeus, triceps and pronator teres are inserted, should be saved in order to preserve tho motions of flexion, extension, partial pronation and supination. Reports from the literature on the value of Vanghetti's Kinoplastic Amputations are accumulating, and the practical application of the principles underlying them should be considered when amputating through the forearm. For description, see page 310.

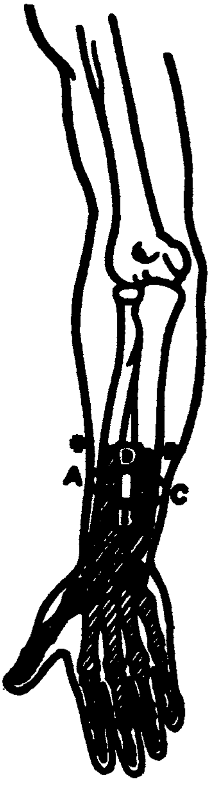


Fig. 65.—Amputation Through the Lower Forearm by a Circular Incision.

Amputation Through the Lower Third of Forearm

The stump is not subjected to any great pressure, so the transverse circular method can be used. The oblique method will be found useful when there is an unequal destruction of tissue as the flap can be taken from any aspect of the arm.

Technic. (Fig. 65).—With the elbow slightly flexed, supinate the arm, indicate the point of bone section on the skin and trace out the circular skin incision ABCD at a distance below the point X, equal to the anteroposterior diameter of the limb at the saw line. Dissect up the cuff of the skin and subcutaneous tissue until the level of the saw line is reached. Divide the muscles and tendons by cutting down on the bone or by transfixion. Thrust the knife between the bones and sever the remaining muscles and the interosseous membrane. Retract the soft parts by a 3-tailed bandage and saw through the bones at the point X. In making the bone section, begin with the ulna and obtain a guiding groove to steady the blade when it cuts through the movable radius. Remove 1 cm. (⅜ in.) of the periosteum and spoon out the marrow canal for a similar distance. Round off the edges and angles of the bone section with a bone-cutting forceps, as depicted in Figures 28 and 29. Secure the radial, ulnar and interosseous vessels, pull down the median and ulnar nerves and shorten them in the usual way. Suture the opposing tendons and fascia. Close the wound with interrupted silk sutures. The resulting cicatrix is terminal.

The *oblique circular* is performed in a similar manner, the only difference being that the plane of section is placed obliquely to the long axis of the limb, the upper end of the incision corresponding to the line of bone section, the lower end lying at a distance below it equal to the diameter of the limb.

Amputation in the Upper Two-thirds of the Forearm

In the upper forearm the best method is by *equal anteroposterior flaps* (Fig. 66). Here, except in wasted subjects, the circular method is contra-indicated on account of the difficulty of obtaining a satisfactory exposure of the bones.

Technic.—The base of each flap equals ½ the circumference of the limb at the saw line; the length equals ½ the circumference of the limb plus the necessary allowance for retraction. Farabeuf calculates the measurement as follows: Given the circumference of the limb in pronation as 8.0 cm. (3 1/5 in.), after retraction the flap should be 4.0 cm. (1.6 in.); hence, when marked on the skin, it should be 6.0 cm. (2 2/5 in.). Supinate the hand and mark out the exterior U-shaped flap ABC. With the hand supine, flex the elbow until the forearm is vertical and mark out the posterior U-shaped flap ADC. Deepen the incisions ABC and ADC to the muscles and allow the skin to retract. With the hand in the original position, divide the supinator longus and flexor muscles of the anterior flap. With the elbow flexed, arm vertical and hand supine, cut the extensor muscles of the posterior flap and divide the remaining muscles and the interosseous membrane. Retract the soft parts with a 3-tailed bandage until the point X is exposed. Make a groove in the ulna to steady the saw, then cut through the more movable radius, remove 1 cm. (2/5 in.) of the periosteum and spoon out the medullary canals for a similar distance. Round off the sharp edges and angles with Liston's bone forceps. Secure the radial artery in the anterior flap just internal to the supinator longus, the ulnar artery over that bone between the flexor sublimis and profundus, the anterior interosseous in front of the membrane and the posterior interosseous between the deep and superficial muscles. Treat the nerves in the usual manner. (Farabeuf recommends

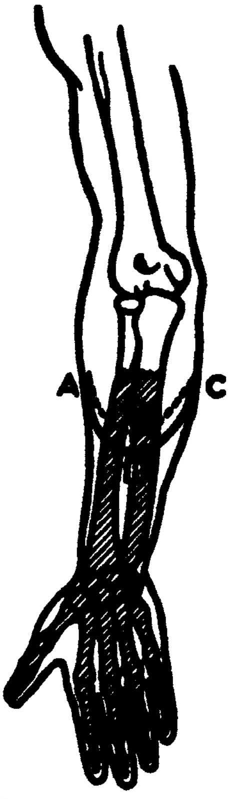


FIG. 66. — AMPUTATION THROUGH THE UPPER TWO-THIRDS OF THE FOREARM BY EQUAL ANTEROPOSTERIOR FLAPS.

that the nerves of the anterior flap be removed for a distance of several centimeters). Unite the structures composing the flaps in 3 distinct layers, first quilt the muscles together, then unite the fascia surrounding them, and finally close the skin with interrupted sutures. Drainage is optional. The resulting cicatrix is terminal and lateral. Place the stump in mid-pronation and bandage it with a light internal rectangular splint, elevate on a pillow or support by a sling. As soon as the wound is healed, Hirsch's systematic course of treatment is to be instituted.

Kineplastic Amputations in the Forearm.—See page 319.

DISARTICULATION AT THE ELBOW

History.—The first recorded disarticulation was performed by Ambrose Paré in 1536. The anterior flap method was developed by Brasdor, Vacquier and Dupuytren. The single external flap (Guerin method) is said to have been performed by Jouliet in 1818. Velpeau, who was a strong advocate of disarticulation, used the circular method. Textor developed the anterior oval method and also used flaps from the lateral and posterior surfaces; Soupart, the posterior elliptical; Neudorfer, the posterior racket.

Anatomical Points.—The guide to the elbow joint is the head of the radius. It can always be felt at the posterior aspect of the elbow. The joint lies about a finger's breadth below the anterior elbow crease.

Indications.—Disarticulation is to be preferred to amputation through the arm, provided the joint is free from disease and that the muscles attached to the upper end of the forearm can be retained. It is easier and more satisfactory to apply an artificial arm to the broad end of the humerus than to a rounded one left after amputation. It is indicated in cases of injury where the radius and ulna are crushed so badly that it is impossible to save any portion of them and in sarcoma of the bones of the forearm.

Methods of Operation.—Various methods of disarticulation at the elbow joint have been described; the oblique circular, transverse circular, large anterior flap, external flap, lateral flaps, anteroposterior flaps, and the racket incision with the handle over the olecranon. In traumatic cases, according to the tissue at hand, the surgeon may safely select any one of the following methods: the oblique circular, external flap, or the lateral flap. Our personal preference is for the oblique.

Oblique Circular Method.—This method may be performed by the anterior elliptical method (Farabeuf) or by the posterior elliptical method (Soupart). Of these the former is the method of choice.

OBLIQUE CIRCULAR BY THE ANTERIOR ELLIPTICAL METHOD (FARABEUF) (Fig. 67).—Locate the joint line, flex the elbow to 135°. The point A is on the anterior surface of the arm over the supinator longus, a hand's breadth below the joint line. The point B is on the dorsal aspect, opposite the tip of the olecranon. The highest point of ellipse is behind, over the olecranon; the lowest is in front, over the supinator longus. Deepen the incision through the fascia and retract the skin. Divide the muscle in the anterior flap by dissection or transfixion. Retract the anterior flap upward until the anterior aspect of the joint capsule is exposed. Divide the external lateral ligament, enter the joint from the outer side, and divide the anterior and interior ligament. Detach the limb by severing the posterior capsule and the triceps. Secure the brachial or, if the bifurcation has taken place, the radial, ulnar, and terminal branches of the superior and inferior profunda and anastomatic arteries. The median nerve is on the ulnar side of the biceps, the ulnar nerve in the notch behind the internal condyle. Pull both nerves down and shorten. Stitch the opposing muscles over the stump, then unite the fascia from before backward, and close the skin with interrupted silk or silkworm-gut sutures. Drain with a small rubber tube for 24 hours. The cicatrix is curved and lies on the posterior aspect of the limb.

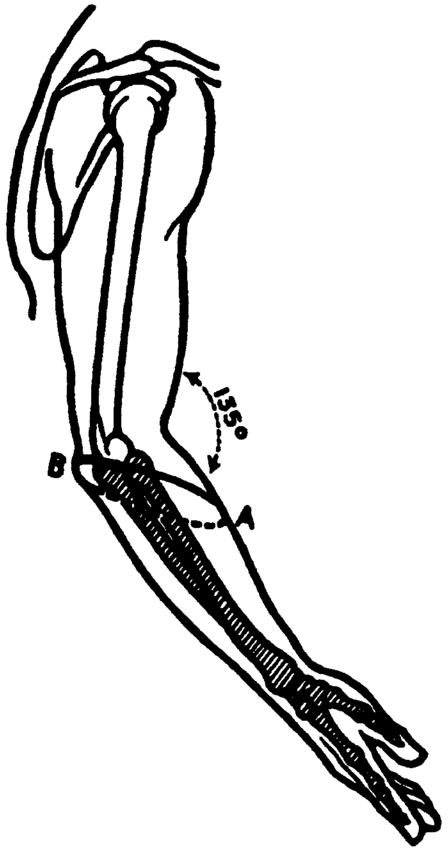


FIG. 67.—DISARTICULATION AT THE ELBOW JOINT BY AN ANTERIOR OBLIQUE INCISION. (Farabeuf Op.)

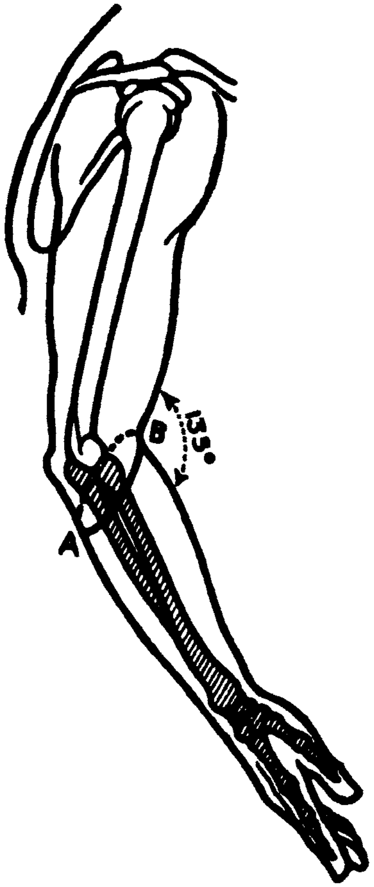


FIG. 68.—DISARTICULATION AT THE ELBOW JOINT BY A POSTERIOR OBLIQUE INCISION. (Soupart-Kocher Op.)

OBLIQUE CIRCULAR BY THE POSTERIOR ELLIPTICAL METHOD (SOUPART-KOCHER) (Fig. 68).—In this method the direction of the ellipse is the reverse of the last method; it is suitable when sufficient skin cannot be obtained for the anterior flap. The upper end of the ellipse is on the anterior surface at the fold of the elbow; the lower end is on the posterior surface, a hand's breadth below the tip of the olecranon. The cicatrix is curved and lies on the anterior surface of the bone.

Circular Method.—This method, though sparing of tissue, is more difficult to perform and trouble is often encountered in covering the condyles. In fact, to overcome the unequal retraction of the skin, the skin incision must be placed obliquely. Over the supinator longus, the incision lies 3 in. (7.5 cm.) below the joint line; over the ulna 1½ in. (3.75 cm.).

After-treatment.—Elevate the stump on a pillow. As soon as the wound is healed, begin a systematic course of massage movements and weight-bearing exercises.

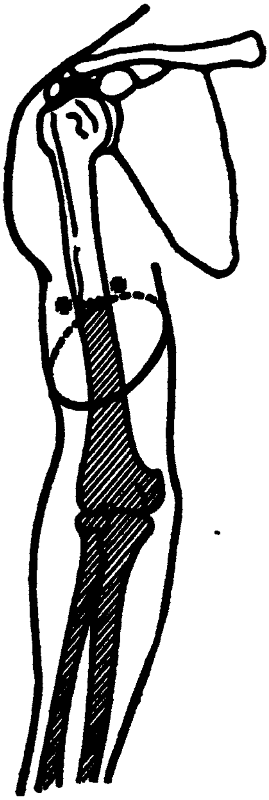


FIG. 69.—AMPUTATION THROUGH THE MIDDLE OF THE ARM BY AN OBLIQUE CIRCULAR INCISION.

AMPUTATION THROUGH THE ARM

Anatomical Points.—In the lower half of the arm the muscles retract readily and about equally; in the upper half the retraction is unequal. The capsule of the shoulder joint descends on the inner aspect of the humerus to the surgical neck. The preservation of the insertions and nerve supply of the deltoid, pectoralis major, and the latissimus dorsi determines the usefulness of an upper arm stump.

Indications.—In the arm a long stump means increased power and leverage for the artificial limb; hence, it is essential to make the bone section as low as possible. In the lower half of the arm this can be best accomplished by the circular method; in the upper half where the retraction is unequal, the method of election is by anteroposterior flaps. In amputation near the joint, damage to the muscles and nerves is avoided by employing Kocher's principle of selective incision; that is, the handle of the racket is placed at the anterior border of the deltoid between the external and internal rotators of the humerus.

Methods of Operation.—These are the transverse circular, oblique circular, tendinoplastic, kineplastic, anteroposterior flaps, and racket or lanceolate.

Circular Method.—This method is best adapted to the amputations through the lower half of the arm.

TECHNIC.—With the arm horizontal and at right angles to the trunk, indicate the point of bone section and mark out a circular incision at a distance below this point equal to 2/3 of the anteroposterior diameter of the limb. Divide the skin and deep fascia, touch with the knife the cellular bands uniting the skin to the deep fascia until the skin is loosened the breadth of 2 fingers. Divide the biceps a thumb's breadth below the edge of the retracted skin. With a circular sweep carry the incision down to the bone, the blade being kept as close to the skin edge as possible, and retract the soft parts 1 cm. above the saw line. Make a circular incision through the periosteum 1 cm. (2/5 in.) above the saw line and reflect the periosteum downward. Saw through the bone at the point X; spoon out the medullary canal for a distance of 1 cm.; round off the edges of the bone with a bone-cutting forceps. The vessels and nerves are dealt with in the usual way. Unite the muscles over the end of the bone, and suture the fascia and the skin. The cicatrix is terminal.

Oblique Circular (Kocher) Method (Fig. 69).—If this method is used, the upper end of the ellipse should be placed over the inner bicipital groove.

Tendinoplastic Method.—This can be used in amputations of the lower portion of the arm, the sawn bone being covered by the triceps tendon.

Kineplastic Method.—See page 319.

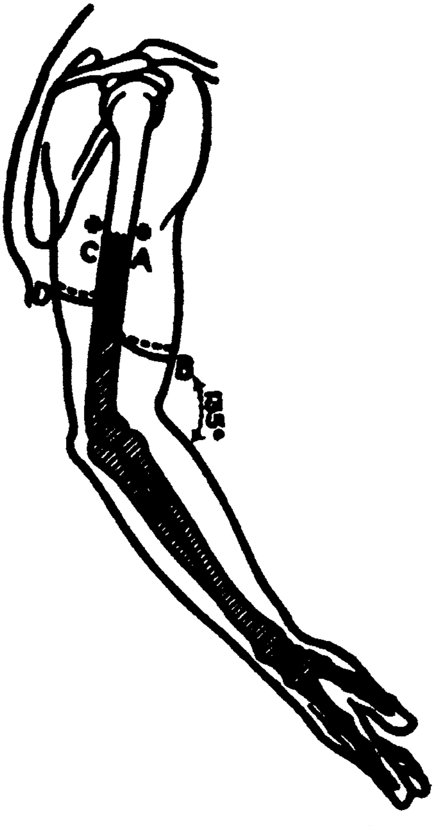


FIG. 70.—AMPUTATION THROUGH THE MIDDLE THIRD OF THE ARM BY A LONG ANTERIOR AND A SHORT POSTERIOR FLAP.

Anteroposterior Flap Method (Fig. 70).—This method is best adapted to amputations just above the middle of the arm. Due allowance must be made for the retraction of the biceps and the anterior flap should be made longer than the posterior.

TECHNIC.—Position as in the circular amputation. Indicate the point of bone section X and mark out the U-shaped anterior flap ABC. The length of the anterior flap is $\frac{1}{3}$ the diameter of the limb at the point of bone section; the base of each flap equals $\frac{1}{2}$ the circumference of the limb. Mark out the posterior flap ABD. This flap is slightly shorter than the anterior one. Deepen the incision through the fascia and allow the skin to retract. If no tourniquet is used, secure the brachial artery at the inner edge of the biceps. Divide the muscles with a circular sweep; retract the soft parts. Before making the bone section remove the musculospiral nerve from its groove and shorten it. Treat the bone by the aperiosteal method; the nerves and vessels as usual.

Anterior Racket or Lanceolate Method (Fig. 71).—The best method in amputation through the upper third of the arm is the anterior racket. If a mobile stump can be obtained, an amputation is preferable to a disarticulation; these conditions can be fulfilled up to the level of the surgical neck, but above this a disarticulation is indicated. As the mobility of the stump depends directly on the preservation of the functions of the muscles, Kocher's principle of selective incisions should be applied and the handle of the racket placed between two groups of muscles supplied by different nerves.

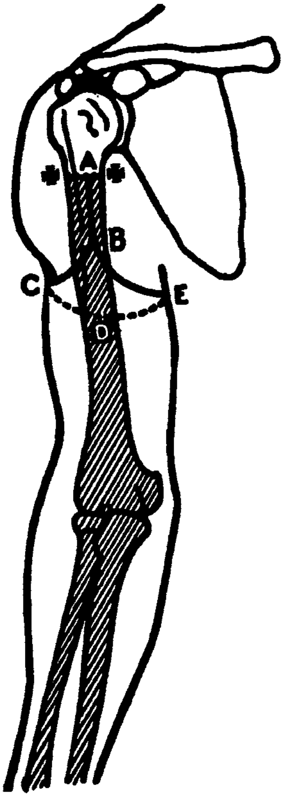


Fig. 71. — Amputation Through the Upper Third of the Arm by an Anterior Racket Incision.

TECHNIC. With the arm slightly abducted and rotated outward, trace the racket incision ABCDE. The point X is the line of bone section. The handle of the racket AB is placed at the anterior border of the deltoid and equals in length three-fifths of the diameter of the arm at X. The circular incision BCDE is placed transversely to the long axis of the limb. The incision AB is carried down to the bone between the external and internal rotators of the humerus. Carry the circular incision BCDE to the bone, retract the soft parts. One centimeter ($\frac{2}{5}$ in.) above the point X, incise the periosteum and detach it downward. Divide the bone at the point X, round off the sharp angles and edges. Make a high division of the nerves and provide new insertion for the pectoralis major coracobrachialis and latissimus dorsi. Attend to hemostasis and suture the wound in three layers. The short stump can be restrained by passing a broad adhesive strap from the anterior chest over the stump to the posterior chest. In amputation through the surgical neck the bone is sawn through between the tuberosities of the humerus and the insertions of the pectoralis major and latissimus dorsi.

Comment.—This latter operation is rarely called for, but the resulting stump is of value in attaching an artificial limb and helps to maintain the normal contour of the shoulder. On account of the growth of the bone from the epiphysis, this operation is not suitable in patients under 16 years of age. In children the tendency to scoliosis after amputation in the neighborhood of the shoulder must be guarded against, and suitable preventive gymnastics should be instituted.

DISARTICULATION AT THE SHOULDER

History.—The first recorded disarticulation was a circular one performed by Morand in 1710. Le Dran, the elder, in 1715, employed an axillary flap. In 1740 Sharp disarticulated by means of a posterior flap. The development of the external or deltoid flap has been attributed to Dupuytren. The names of Paroisse (1800), Grosbois (1803), and Charles Bell (1808) are also associated with it. V. Walther (1810) used a long deltoid and a short internal flap. The oval method was employed by Guthrie in the early part of the nineteenth century, by Scoutetten in 1827; the exterior racket by Larrey and the anterior racket by Spence in 1865. It is interesting to note that Larrey, during the wars of Napoleon, lost only 10 cases out of 100. Considering the unfavorable circumstances under which he worked, this is a remarkable result.

Control of Hemorrhage During Disarticulation at the Shoulder. (1) LIGATION OF THE VESSELS. The simplest and best method is to ligate the vessels on the inner aspect of the arm before they are cut. They can also be secured low down in the flap, as is done in the amputation resection method. If the axilla be invaded by a new growth, it may be necessary to tie the first portion of the axillary or make a temporary or permanent ligation of the subclavian.

(2) MANUAL OR INSTRUMENTAL COMPRESSION OF THE FLAP CONTAINING THE VESSELS. Manual compression necessitates the presence of an extra assistant; instrumental compression can be accomplished by using a Lynn Thomas forceps-tourniquet.

(3) COMPRESSION OF THE SUBCLAVIAN BY FINGER PAD, KEY, ETC.—This method is uncertain, unsatisfactory, and often impracticable.

(4) CONTROL OF HEMORRHAGE BY THE ELASTIC CONSTRICTOR. The constrictor is wound around the shoulder back of the coracoid and acromion processes, and secured. The weakness of the method is the possibility of the constrictor slipping; to obviate this the loop of a bandage can be passed under it and the constrictor pulled toward the opposite shoulder, or the tubing can be applied with a double turn around the shoulder and finished by making a figure-of-eight across the chest under the axilla. Slipping can also be prevented by Wyeth's pins. These uncertain procedures are not recommended, as they are inferior to the simple procedure of finding and securing the vessels.

Anatomical Points. The round prominence of the shoulder represents the tuberosities of the humerus covered by the deltoid. The cephalic vein runs in the groove between the pectoralis major and the deltoid. The skin over the deltoid is thick and adherent and retracts to a great extent.

Indications.—If conditions require the removal of the arm at a level above the surgical neck, a disarticulation is superior to an amputation. Formerly, in both civil and military practice, especially the latter, this operation was performed frequently; today improvements in the facilities for conservative treatment have greatly reduced the number of cases requiring disarticulation.

In civil practice this operation is in active use in accidents, etc., in which the arm is partially or completely torn away, badly mangled, infected, or where the humerus is involved by malignant growths.

Methods of Operation.—Farabeuf describes over 30 procedures for removal of the arm. It is hardly just to dignify all these procedures as different methods, for the great majority differ only in minor details.

Of necessity the selection of a method for an individual case must depend on the extent of the soft parts available. In traumatic cases with considerable laceration of the soft parts the covering can be obtained from the remaining sound tissues; skin flaps can be taken from the chest. In malignant cases the skin furthest from the growth is employed.

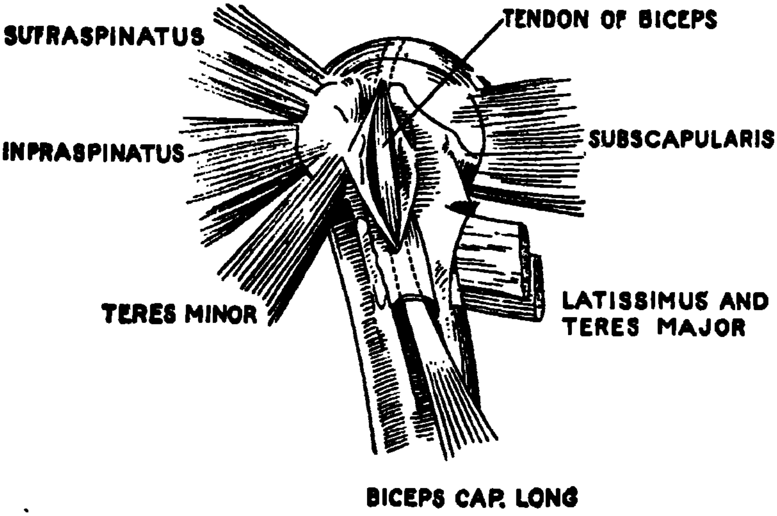


Fig. 72.—Insertions of Muscles of the Greater and Lesser Tuberosity of the Humerus.

The methods of choice are the anterior racket (Kocher's modification of Spence's method), amputation-resection, and the lanceolate methods.

Other methods are the circular, elliptical, anterior and posterior, and lateral and deltoid flaps, and the external racket (Larrey).

Anterior Racket Method (Figs. 73A, 73B).—Disarticulation of the shoulder joint is best performed by this method. It consists of a circular incision at the level of the axilla, with a longitudinal incision placed between the anterior border of the deltoid and the pectoralis major. The longitudinal incision fulfills Kocher's principle of selective incisions, as the handle of the racket falls between two groups of muscles supplied by different nerves.

Technic.—With the arm in slight abduction, rotate the head outward and mark out the incision ABCDE. The point A is over the clavicle, just to the outer side of the coracoid process. BCDE passes around the arm at the level of the axilla. The incision AB passes through the upper fibers of the deltoid, then in the interval between the deltoid and pectoralis major to the bone.

Ligate the cephalic vein and the branches from the acromiothoracic axis, lay open the bicipital groove, and follow the tendon into the capsule of the joint. Detach the insertion of the subscapularis from the lesser tuberosity, the pectoralis major from the anterior lip of the bicipital groove; the latissimus dorsi and the teres major from the posterior; the insertions of the supraspinatus, infraspinatus and the teres minor from the greater tuberosity; and force the head upward and forward out of the wound. Now deepen the circular incision BCDE. Isolate the vessels and nerves, ligate the former, and after a preliminary injection with novocain make a high division of the latter. Complete the disarticulation by dividing the remaining soft parts. Suture the muscles and close the wound so that a vertical cicatrix results. In order to preserve the nutrition and the innervation of the deltoid, care must be taken to avoid injuring the posterior circumflex nerves and vessels. The injury is most likely to take place as the structures wind around the back of the arm; to avoid this the operator must hug the bone as he shells out the humerus. The importance of protecting the nerve lies in the fact that the deltoid is the principal muscle in the stump, and any diminution in its function would seriously impair the value of an artificial limb.

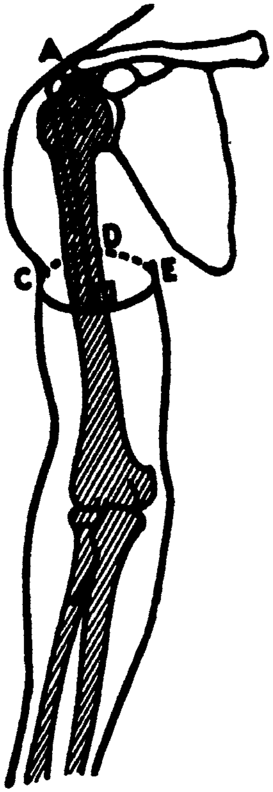


FIG. 73A.—DISARTICULATION AT THE SHOULDER JOINT BY AN ANTERIOR RACKET INCISION. (Spence Op.)

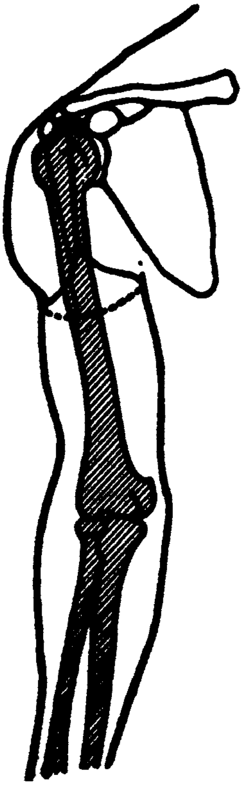


FIG. 73B.—DISARTICULATION AT THE SHOULDER JOINT. (Kocher Op.)

Amputation-resection Method.—This operation is in reality a modification of the preceding one, and is analogous to the amputation-resection method employed at the hip.

TECHNIC.—In emptying the blood from the limb, apply an elastic tourniquet at the shoulder, prevent its slipping by Wyeth's pins or by winding it in a figure-of-eight under the opposite shoulder. Draw the affected shoulder over the edge of the table, abduct the arm to a right angle. At the level of the deltoid insertion make the circular incision ABC. Perform a circular amputation, severing the bone at this level. Ligate the axillary vessels and re-

move the constrictor. Grasp the bone stump with lion-jawed forceps. Make the vertical incision AD in the line of the bicipital groove, then proceed to shell out the head of the bone as in an excision of the shoulder. The remaining steps correspond to the preceding operation.

The Lanceolate Method (Fig. 74).—This method is to be employed when all the soft tissues surrounding the shoulder have to be removed or are wanting.

TECHNIC.—Outline the lanceolate incision ABDC. The point A is just external to the coracoid process. The point B is just below the junction of the anterior axillary fold and the arm; the point D is just below the junction of the arm and posterior fold; the point C is external to the acromion. Deepen the incision ACD in an obliquely slanting manner, cut through the deltoid, and enter the joint. Approach the axillary vessels from the front through the incision AB. Ligate the vessels in turn and complete the operation by cutting through the soft parts in the inner side of the arm. Treat the nerves in the usual manner. If the available skin flaps are too scanty, saw off portions of the clavicle and the acromion, or provide autoplastic flaps from the chest wall.

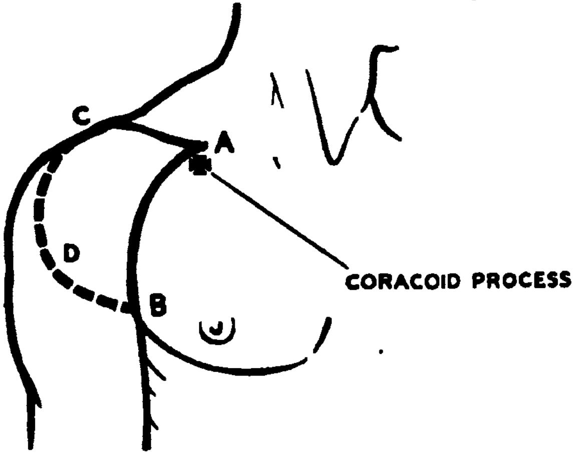


FIG. 74.—DISARTICULATION OF THE ARM BY THE LANCEOLATE METHOD.

Comment.—The above description of the anterior racket method follows Kocher's modification of Spence's disarticulation. No other muscle flap incision compares with this bloodless disarticulation-resection method. It is easy to perform as the blood vessels can be readily kept under control, and it yields a well-rounded stump with a vertical cicatrix to which an artificial limb can be fixed. Furneaux-Jordan's method is a modification of this. It is of special value in those cases where the soft parts about the shoulder are intact and the bone is split up into the joint. Larrey's external racket incision cannot be considered a method of choice, as the division of the posterior circumflex nerve leads to paralysis of the deltoid. The lanceolate method is employed in the destruction of the soft parts around the shoulder and in operations requiring the sacrifice of the muscles.

REMOVAL OF THE SHOULDER GIRDLE WITH THE ARM: INTERSCAPULOTHORACIC AMPUTATION

History.—A patient was successfully treated by Cheselden at St. Thomas's Hospital, London, in 1787, for a traumatic amputation of the arm and scapula. The first recorded interscapulothoracic amputation was performed by an English naval surgeon, Ralph Cuming, in 1808, the indication for the operation being a severe gunshot wound. The first American surgeon to perform this operation was Dixi Crosby, of New Hampshire (1836). Mussey (1837) disarticulated the sternal end of the clavicle and compressed the subclavian. Crosty (Kocher) operated for tumor in 1886. Berger's exhaustive monograph (5) appeared in 1887, and did much to perfect the operation. Le Conte (1899) advised the disarticulation of the sternal end of the clavicle with ligation of the subclavian vessels in preference to the resection of the portion of the clavicle.

Indications. This operation is indicated in severe extensive injuries of the shoulder girdle; in malignant growths of the arm, scapula or axilla; at times in persistent carcinoma of the breast; in spreading cellulitis and gangrene. The relatively benign bone tumors, giant celled sarcomata, enchondromata, and myxomata are treated by excision. Before performing the operation for malignancy, the mobility of the shoulder girdle, and especially of the scapula, should be determined.

Methods of Operation. In traumatic and malignant cases in which the clavicle and its attached muscles remain uninvolved, the Berger-Farabeuf technic is employed; in all others Le Conte's clavicular disarticulation procedure is to be used. In the Berger-Farabeuf operation a modified lanceolate incision is used, the middle third of the clavicle is resected, and the subclavian vessels ligated. In the Le Conte method the clavicle is disarticulated at its sternal end. Anesthesia is best administered by the intratracheal method and the nerves of the brachial plexus blocked by 1 per cent. novocain.

Berger-Farabeuf Method (Figs. 75, 76). The following description follows that of Berger and Farabeuf: Berger clearly pointed out that the success of the operation depends on the control of the hemorrhage and the attaining of such control constitutes the first step in the operation. The form of the skin incision must of necessity depend on the healthy condition of the soft parts; a lanceolate incision with antero-inferior (pecto-axillary) and a posterosuperior (cervicoscapular) flap is the incision of choice. For convenience of description the operation can be divided into three stages: the first stage, exposure and ligation of the subclavian vessels; the second stage, the dissection of the flaps; the third stage, the removal of the limb.

TECHNIC. FIRST STAGE.—The object of this stage is the ligation of the axillary vessels. Apply an Esmarch bandage to expel the blood from the arm. Draw the shoulder well over the edge of the table. Mark out the incision ABCDE. With arm by the side, make the incision AB about 10 cm. (4 in.) long directly over the clavicle. The point A is 2 fingers' breadth external to the sternoclavicular joint; B is immediately over the acromioclavicular joint. Deepen the incision AB to the bone, free the periosteum over the middle third of the clavicle; pass a blunt hook under the bared bone and divide it with a Gigli saw at the point X. Raise the exterior portion of the clavicle with a lion-jawed forceps and complete the separation of the periosteum on its posterior surface. Saw through the bone at the deltoid tubercle (Y). Many operators prefer to resect the clavicle without removing the periosteum. The subclavius muscle is raised and carefully divided at the inner aspect of the wound. Expose the trunks of the brachial plexus and, before dividing them, inject the individual cords with novocain. The axillary vein will be found immediately behind the subclavius, separated from it by a varying amount of fascia. The artery lies in a more posterior plane below the nerves. Secure the artery, then the vein, and divide between double ligatures. Identify the scalenus anticus and ligate the branches of the subclavian as they pass outward in front of the muscle. The ascending cervical passes upward, the superficial cervical upward and outward, the suprascapular horizontally beneath the clavicle, and the transversalis colli passes over or through the brachial plexus. This completes the first stage of the operation.

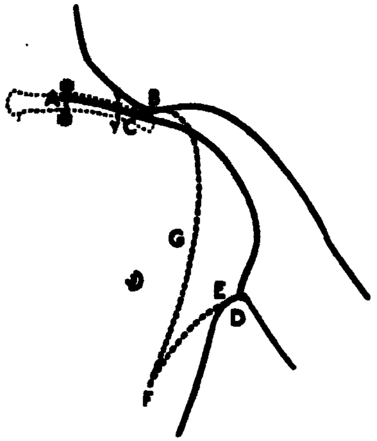


FIG. 75.—INTERSCAPULOTHORACIC AMPUTATION. Anterior view. (Berger-Farabeuf Op.)

SECOND STAGE.—This consists in the formation of the flaps. Draw the arm well away from the body and outline the incision CDEFB. The point C represents the center of the incision and the clavicle; the point D, the junction of the anterior axillary fold with the arm; the point E, the corresponding junction of the posterior fold; the point F, the apex of the scapula. The portion of the incision CD runs downward and outward just above the coracoid, and then parallel with and a little external to the pectodeltoid sulcus; the line DE runs transversely across the inner aspect of the arm to the posterior axillary fold. Expose the back of the thorax by pulling the raised arm forcibly upward. Carry the incision EF downward and inward to the inferior angle of the scapula. Divide the pectoralis major in the line of the incision, the pectoralis minor close to the coracoid process, and open up the axilla. If there is muscular or glandular involvement in the axilla, divide the muscles at their origins, and, if not involved, divide at their insertions. Carry the incision DEF to the back, dividing the latissimus dorsi close to the chest wall. This completes the formation of the thoraco-axillary flap. Draw the arm across the body, roll the patient toward the sound side, and mark out the coracodorsal flap FGB. This extends from the outer

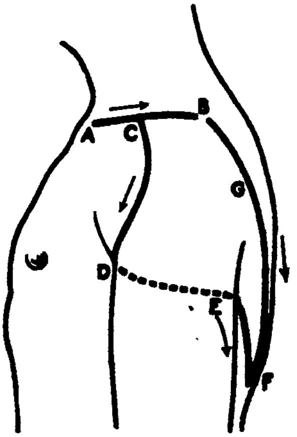


FIG. 76.—INTERSCAPULOTHORACIC AMPUTATION. Lateral view. (Berger-Farabeuf Op.)

end of the original clavicular incision B straight back over the spine of the scapula G to the inferior angle of the bone F. Dissect back the skin and fascia to the vertebral border of the scapula.

THIRD STAGE.—This constitutes the removal of the limb. Detach the trapezius from the upper border of the clavicle and acromion process; rotate the arm outward to obtain a good exposure of the muscles on the ventral surface of the scapula; divide the attachments of the levator anguli scapulæ, serratus magnus, and rhomboid muscles at the vertebral border. Draw the arm outward and complete the separation by dividing the omohyoid at the upper border of the scapula and the trapezius at the spine. Provide drainage and close in the usual manner. The scar runs obliquely downward, outward, and backward.

Le Conte's Method.—The following is Le Conte's description of his operation (56):

> "(1) The incision is begun over the sternal end of the clavicle, carried along that bone to about its middle, and then curved downward to the anterior axillary fold. The skin and superficial fascia are dissected up, exposing well the inner two-thirds of the clavicle.
>
> "(2) The clavicle is disarticulated by severing its attachments to the sternum and the rhomboid ligament, the clavicular attachment of the sternocleidomastoid muscle is cut close to the bone and the clavicular portion of the pectoralis major is separated with the finger from the costal portion of the muscle up to the anterior axillary fold.
>
> "(3) The clavicle is now pulled upward and outward, and if the subclavius muscle does not readily strip off, its attachment to the first rib is divided. The pectoralis minor will now be well exposed. It is divided, and the coracoid portion reflected upward with the clavicle. This exposes the axilla fully, and the vessels are seen traversing it from the anterior scalenus muscle down.
>
> "(4) The sheath of the vessels is opened and the vein dissected away from the underlying artery. Two ligatures are passed around the vein, but these are not tied until the arm is blanched. This renders the use of an Esmarch bandage unnecessary. It must be noted that the cephalic vein has joined the axillary below these ligatures, or else separate ligature of that vessel is required.
>
> "(5) The vessels are now severed, together with the brachial plexus of nerves, and the costal portion of the pectoralis major. This completes the division of the anterior attachments of the arm.
>
> "(6) A posterior incision is now carried from some point on the anterior incision (as near the tumor as it is deemed advisable to go) directly backward and downward to the inferior angle of the scapula, and up again to the posterior axillary fold. The skin and superficial fascia are dissected up for a short distance (half an inch to an inch).
>
> "(7) The trapezius is now severed and the transversalis colli or posterior scapular artery secured; the omohyoid muscle is cut and the suprascapular artery secured. The muscles attached to the inner border of the scapula are rapidly divided close to the bone; the serratus magnus and latissimus dorsi are then cut, the latter at the posterior axillary fold. The arm is now held to the body by the skin of the axilla alone. If there is sufficient flap to cover the wound, the anterior and posterior incisions are joined through the axilla, but if more skin is needed, a flap may be raised from the under surface of the arm. The wound is then closed with suitable provision for drainage.

"The procedure just detailed seems to have the following advantages:

"(a) It gives the widest and fullest possible exposure of the vessels, and decreases the accidents of ligation to a minimum.

"(b) The disarticulation of the clavicle is simpler, quicker, and easier than a resection of the bone, and the danger of wounding important vessels is less because these structures are well protected by the sternohyoid and sternothyroid muscles.

"(c) The elevation of the arm, after securing the artery and before the vein is tied, makes a practically bloodless amputation.

"(d) The suprascapular and posterior scapular arteries (the only other vessels that can bleed) are easily picked up before being cut.

"(e) In malignant growths, where the outer end of the clavicle is involved, there is less risk of a return if the entire bone with its periosteum is removed.

"(f) It removes everything in one piece, a more surgical procedure when dealing with malignant growths."

After-Care.—A firm dressing is applied, and if the condition warrants it, the patient is placed in a semi-sitting position. As soon as the wound is healed, an artificial arm is fitted and gymnastic exercises to check the tendency to scoliosis are instituted. If the patient complains of a feeling of lopsidedness, the weight of the artificial limb will tend to correct this.

Comment.—It has been urged that Le Conte's method entailed the additional dangers of wounding the pleura and innominate vein. An examination of the reported cases does not confirm this. Relatively speaking, more accidents have occurred in the resection method.

Keen, in a case where it was evident that in excising the tumor he would remove such a large portion of the skin that the edges could not be approximated, obtained a flap from the healthy skin of the inner arm. The flap extended to the elbow and was turned up so that the lowest end near the elbow became the highest in the neck. In order to safeguard the vessels from being wounded, Ollier advocated a preliminary detachment of the periosteum. This step is unnecessary, takes more time, and in the face of malignancy is not good surgical practice.

Dangers.—HEMORRHAGE FROM THE MAIN TRUNK OR FROM THE BRANCHES.—In a large growth we must expect to encounter numerous large anastomosing veins. The bleeding can be reduced to a minimum by an early ligation of the subclavian with its branches supplying this region, and by the use of a Lynn-Thomas forceps on the broad muscle pedicle.

SHOCK.—In the ordinary case shock does not seem to play such an important rôle as in amputation of the hip. Hemorrhagic shock is prevented during the operation by the preliminary emptying of the blood-vessels, tying of the artery before the vein, and careful hemostasis. Nerve shock is prevented by gentle handling and by blocking the nerves with novocain. After the operation shock is combated by bandaging the legs and abdomen, by hypodermoclysis, saline infusion, transfusion, etc. Entrance of air into the veins is a rare complication. If it occurs, proximal pressure with a wet swab is applied and the veins secured. Infection and pneumonia accompanying this extensive operation are possible surgical risks; a careful technic and avoidance of exposure will diminish these complications.

Results.—Jeanbran and Riche (1905) have reported on the final result in 188 cases of interscapulothoracic amputations for malignant tumors. Before 1887 the mortality was 29.16 per cent.; from 1887 to 1905, 7.84 per cent. in growths of the humerus the mortality was 2.75 per cent.; of the scapula, 23.80 per cent.; of the soft parts, 11.76 per cent. In 105 cases the average length of life was 35 months. Twenty-4 cases were living after more than 5 years. In 20 cases, 3 lived more than 10 years, 2 more than 13, 1, 15, and 1, 16. Syme's case lived 26 years and was afterward lost sight of.

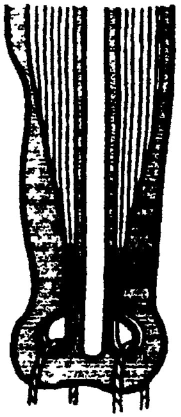


FIG. 77 KINEPLASTIC METHOD.

KINEPLASTIC AMPUTATIONS (VANGHETTI-CECI)

History.—Guiliano Vanghetti, an enthusiastic medical practitioner of Empoli, Tuscany, was the discoverer of the kineplastic method of amputating. The principles were clearly formulated by him in 1896 as the result of a remarkable series of experiments performed on chickens. His first publication appeared in 1898 (91). He showed that, if the distal portion of a muscle or tendon be freed from its insertion and covered by skin, the muscle retains its voluntary power of contraction. By forming the muscles and tendons into rings or knobs, and attaching cords to these, he was able to control an artificial appliance. Besides governing the movements of the artificial members (by the muscular contraction), he secured a more intimate attachment to the body. Vanghetti was without hospital connections and lacked the opportunity of applying his principles to the human, but succeeded in interesting Ceci, of Pisa (1898), who performed the first kineplastic operation in 1900. Other pioneers in this field were De Francesco (1906), Elgart (1907), and Vrédène (1908).

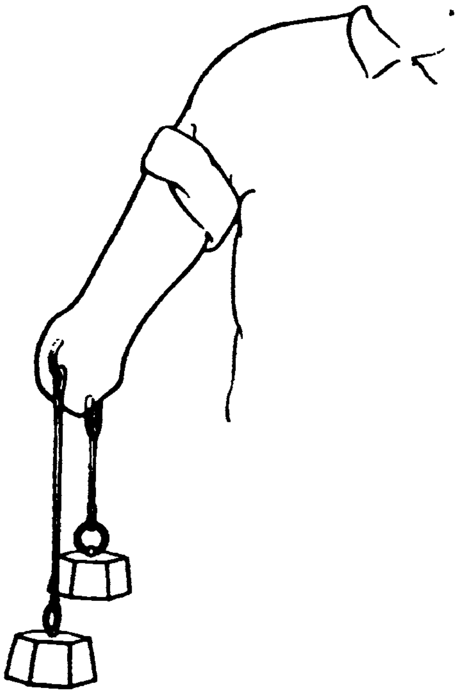


FIG. 78.—METHOD OF EXERCISING THE TENDINOMUSCULAR MOTOR. (Ceci.)

The principal function of the stump in the upper extremity is *the control* *of the artificial limb.* Kineplastic methods furnish ideal voluntary control of the artificial limb by means of living muscular motors with an intimate connection between the stump and the prosthetic apparatus.

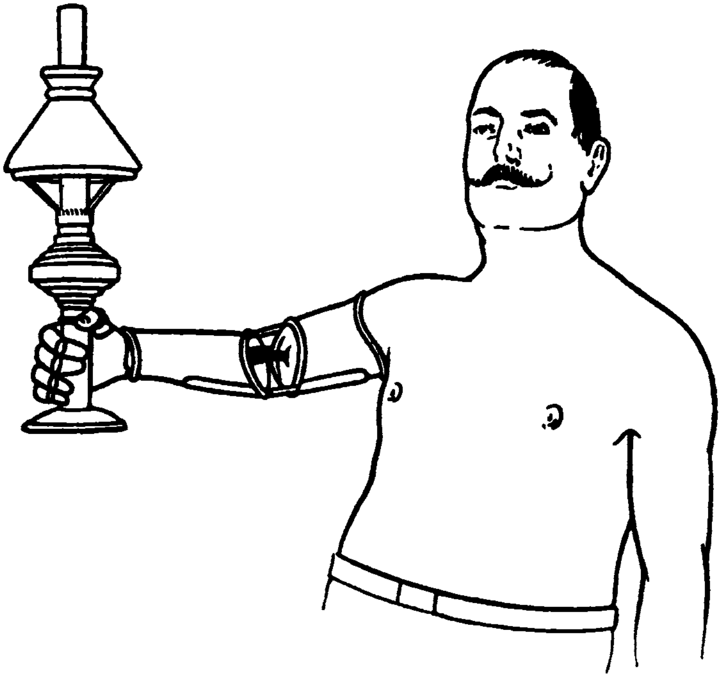


Fig. 79.—Result of a Kineplastic Amputation of Arm. (Ceci.)

Four variations in *the transmission of the power to the artificial limb* have been developed:

1. Single and double plastic loop.
2. Plastic club motor, with detached bone (De Francesco).
3. Compound tendon loop (Vrédène).
4. Elgart's method of transforming lateral rotary movements into flexion and extension.

1. **Single or Double Plastic Loop** (Figs. 78, 79).—These were the methods used by Ceci, who did not follow Vanghetti's minute rules of isolating each muscle and tendon separately, but aimed to leave the muscle, etc., in as nearly a physiological and anatomical relationship as possible, thus preserving their nutrition. The following is Ceci's description (22). The case was a myxosarcoma of the radius with glandular involvement of the lower axilla, for which "a kineplastic amputation through the lower one-third of the humerus, with an axillary dissection, was performed (1900):

> "A. An incision, two fingers' breadth below the fold of the elbow, was made through the skin and subcutaneous tissue, and the cutaneous cuff reflected to the junction of the middle and upper third of the arm.

"B. The tendon of the biceps was carefully detached from the radius and the tendon of the triceps from its insertion in the olecranon.

"C. A circular incision was made down to the humerus, the periosteal cuff reflected and the bone sawn through at the inferior third of the arm.

"D. The elastic constrictor was removed, all bleeding checked, the nerve trunks resected, the tendon of the biceps sutured to that of the triceps. In this manner a loop or stirrup was formed.

"E. Three cm. from the free edge of the cutaneous cuff two lateral 5-cm. incisions were made. The cutaneous cuff was placed over the tendinous ring and the edges were sutured, forming a buttonhole in the center of the tendinous loop.

"F. Lastly, the inferior border of the cutaneous cuff was sutured in a sagittal direction. A muscle-tendinous loop, entirely covered with skin and subcutaneous tissue, was produced. After the operation and during the subsequent dressings, the buttonhole was packed with gauze to keep it patent. The extensive flap of skin and subcutaneous tissue atrophied rapidly. With the solidification of the cicatrix, exercises of traction on the ring were commenced. The patient little by little could raise heavy weights by muscular contraction, and was able to lift two kilos." (Fig. 78.)

"Kineplastic amputation through the forearm with double plastic loop motor (1906) (Fig. 80).

"A. A circular incision was made in the inferior one-fourth of the forearm, and was deepened to the bone at the level of the retracted skin; the bone sawn through and the tuberculous focus gotten rid of.

"B. Two lateral incisions 15 cm. were carried down to the bone, one over the radius and the other over the ulna.

"C. The quadrangular flaps of skin and subcutaneous tissue were dissected up to the upper third of the forearm along with the corresponding musculotendinous flaps. At the root of the latter, after having divided the deep muscles and formed a periosteal cuff, the radius and ulna were divided, the radial and ulnar arteries tied, the elastic constrictor removed, careful hemostasis made and the nerve trunks divided.

"D. The dorsal muscles of the cutaneous flap were divided into halves according to their tendons. The extremities of the tendons of one half were sutured to the tendons of the other half, so that each musculotendinous flap formed a ring or stirrup. The same procedure was applied to the ventral flap. The musculotendinous rings were covered with skin in the following manner: Two 3 cm. buttonhole incisions were made, one in the proximal and one in the distal. The latter was 2 cm. from the free edge of the flap. The two incisions were 2 cm. apart. The two incisions of each flap were placed at the same level and the cutaneous flap folded over the respective musculotendinous rings. The edges of the buttonhole incision, then the longitudinal edges, were united with a continuous silk suture. The inferior edges of each flap were turned up to the level of the sawed bone. Four drains were inserted at the distances of the respective flaps to provide drainage and prevent necrosis. In this way the stump of the forearm was provided with two ring motors completely covered by skin. A rubber tube was inserted in each ring. Cicatrization being completed in two months, traction exercises were commenced. The rings functionated as two motors controlled by the will, the patient opening the hand by contracting the dorsal motor and closing it by contracting the ventral motor."

2. Plastic Club Motor with Detached Bone (De Francesco, 1906) (Fig. 81).—A circular amputation of the forearm is performed and a longitudinal

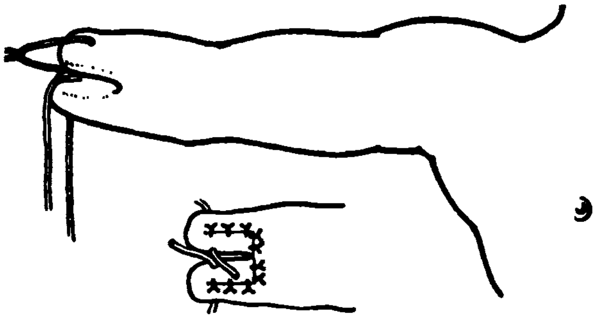


FIG. 80.—KINEPLASTIC AMPUTATION OF FOREARM. (Vanghetti-Ceci.)

incision made on each side, exposing the radius and ulna. A portion of both bones equal to 2.5 cm. (1 in.) is removed. This section is made 2 cm. (4/5 in.) above the sawed ends of the bone. The amputation wound and the lateral incisions are sutured. Traction is then applied to the osseous musculotendinous club by means of an apparatus depicted in Figure 82. When the wound is

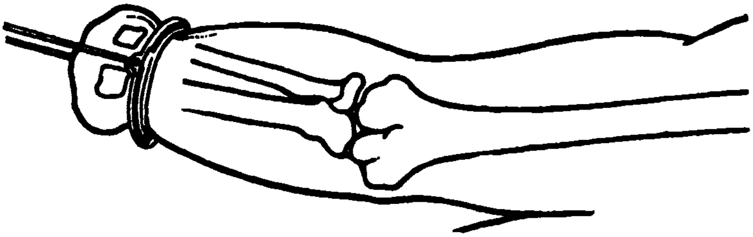


FIG. 81.—KINEPLASTIC AMPUTATION OF THE FOREARM, DE FRANCESCO MODIFICATION. (After De Francesco.)

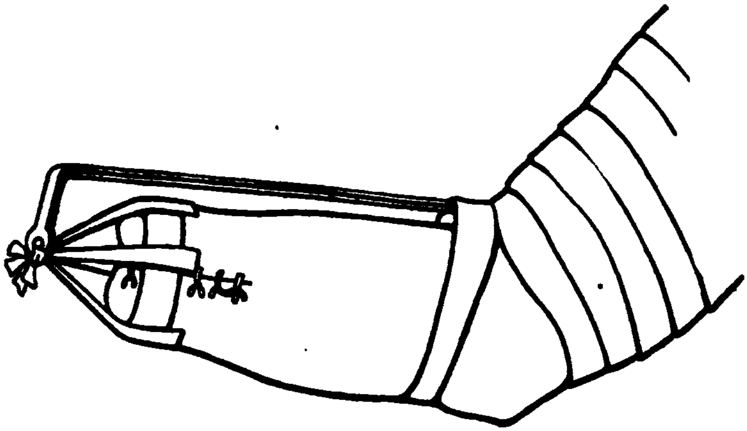


FIG. 82.—DE FRANCESCO'S SPLINT, TO PROVIDE TRACTION DURING THE HEALING PROCESS. (De Francesco.)

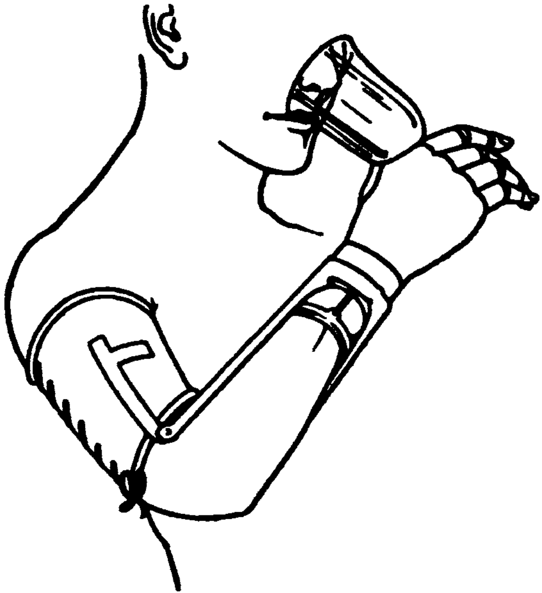


FIG. 83.—RESULT OF DE FRANCESCO'S MODIFICATION. (After De Francesco.)

healed, a rubber padded ring is applied around the knob. From this ring cords pass to the artificial limb. Voluntary flexion of the fingers is possible by traction on the cords; relaxation loosens the fingers (Fig. 83).

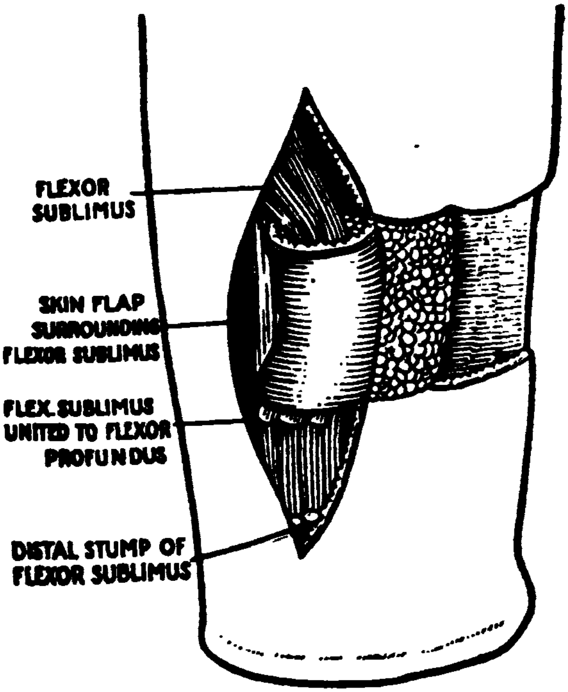

FLEXOR SUBLIMUS
SKIN FLAP SURROUNDING FLEXOR SUBLIMUS
FLEX. SUBLIMUS UNITED TO FLEXOR PROFUNDUS
DISTAL STUMP OF FLEXOR SUBLIMUS

FIG. 84.—KINEPLASTIC AMPUTATION OF FOREARM, VRÉDÈNE'S MODIFICATION. Formation of tendon loop.

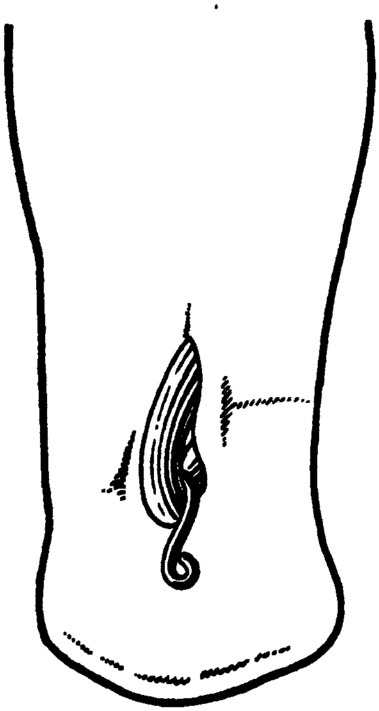


FIG. 85.—TENDON LOOP COMPLETED. (After Vrédène.)

3. Compound Tendon Loop (Vrédène, 1908) (Figs. 84, 85).—Vrédène applied Vanghetti's method in a case of precarpal amputation of the hand, making use of the superficial and deep tendons of the forearm to supply the power. An anterior longitudinal incision is made over the flexor tendons of the forearm, the superficial flexors are divided, a loop made and their cut ends sutured to the anterior surface of the deep flexors. This tendon loop is then enveloped by pedicle skin flaps, the fat surface being applied against the tendons. The wounds are then closed as far as possible, and at the end of two weeks, if the nutrition of the flaps warrant it, the pedicles are cut. In Vrédène's case exercises were begun within a month, and the tendinous loop could exert a pull of 12 pounds. An artificial hand to fit this stump can be constructed, in which the thumb and middle and index fingers are flexed by means of the tendon loop and a metal hook.

4. Elgart's Method of Transforming Lateral Rotary Movements into Flexion and Extension (Fig. 86).—Elgart called attention to the possibilities

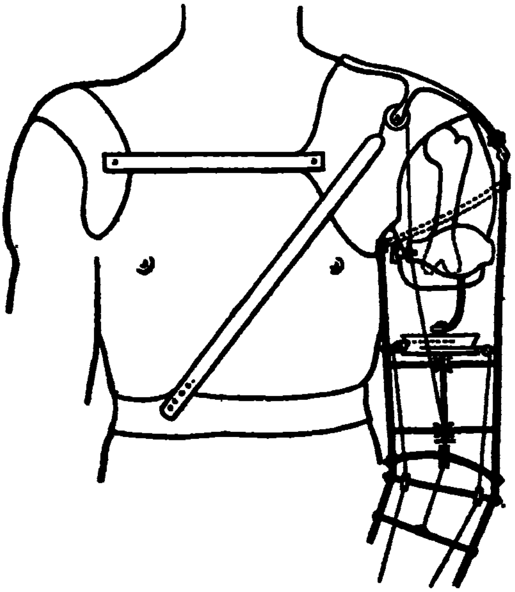


FIG. 86.—PROSTHETIC APPARATUS USED BY ELGART IN HIS KINEPLASTIC AMPUTATION. (After Elgart.)

of this procedure in a case of a conical stump (1907). He split the humerus and pried the ends apart, giving the bone stump the character of an inverted Y. To this broad flat stump a compression cuff was applied. The cuff, following the rotary movements of the stump, transmitted the power to cords, which in turn transformed the rotary motion into flexion and extension. The operation was performed as follows:

> "The conical bone stump was exposed. The skin and muscles first being reflected upward, a bony wedge was removed from the humerus and the ends pried apart for a distance of 30 degrees, care being taken to preserve the musculoperiosteal attachments. The muscles were then sutured over the diverging bone ends, providing the humerus with new plastic condyles."

Comment.—Kineplastic methods open new fields of activity and ingenuity for the surgeon. The method has not been in use long enough to lay down definite indications or to state the correct type of kineplastic amputation that should be employed. The methods which are useful in the upper extremities are of little value in the lower. Theoretically, this would seem the best type of amputation to use in children where the possibility of a conical stump may arise; and if a conical stump be already present, it is the best method of treating it. Binnie states that kineplastic amputations "have lost much of their desirability since Carnes devised his artificial arms." It is contra-indicated in traumatic cases, in cases with poor circulation and those of doubtful asepsis. Ceci does not follow Vanghetti's minute rules for the isolation of tendons and muscles, but, on the contrary, leaves the muscles and tendons as far as possible in their physiological and anatomical relations, providing for them the best possible nutrition. For this reason he employs the muscles and tendons in their ensemble, flexors in one group, and extensors in another, isolating only when the muscles are of large dimensions, as the biceps, triceps and brachialis anticus.

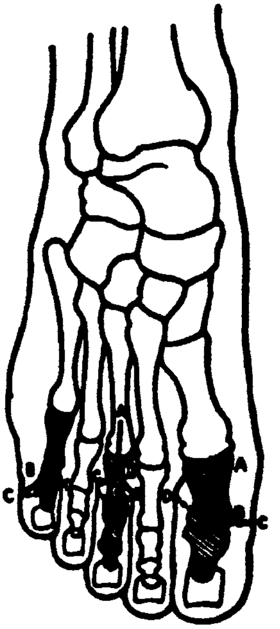


FIG. 87. — DISARTICULATION OF THE TOES. Disarticulation of the great toe at the metatarsophalangeal joint by the internoplantar flap. (Farabeuf Op.) Disarticulation of the middle toe at the metatarsophalangeal joint by the dorsal racket. Disarticulation of the little toe at the metatarsophalangeal joint by the externoplantar flap. (Farabeuf Op.)

LOWER EXTREMITY

AMPUTATIONS OF TOES

Anatomical Points.—The weight of the body is transmitted to the foot through the heel and the heads of the metatarsals. The fact that the first metatarsal receives most of this weight makes it important to preserve this structure. Weight-bearing being the main function of a lower extremity stump, the cicatrix must be so placed that it will be protected from all pressure. In disarticulation at the metatarsophalangeal joint the relatively large size of the head of the first metatarsal should be kept in mind and ample provision made for its covering.

General Considerations.—A disarticulation at the metatarsophalangeal joint is to be preferred to a partial amputation. The short stump left after the partial amputation is often useless, and if contraction takes place, we have a troublesome cocked-up stump, which will be rubbed by the shoe.

These reasons make it advisable to perform a disarticulation rather than a partial amputation in the 3 outer toes. Portions of the first and second toes should be saved: the great toe to preserve the strength of the ball of the foot; the second toe to prevent the outward deflexion of the great toe which might otherwise result in a hallux valgus.

Methods.—For the phalanges and interphalangeal joints the best methods are the single plantar flap and the oblique circular.

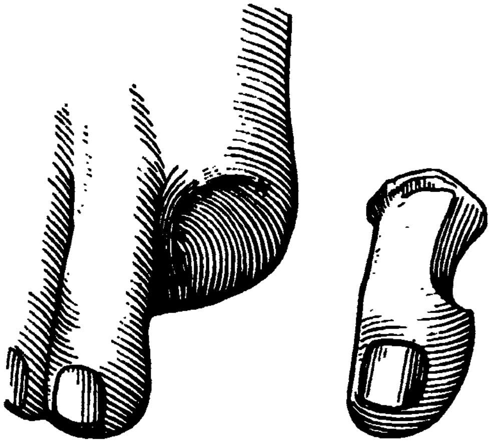


Fig. 88.—Disarticulation of the Great Toe by Internoplantar Flap. (Farabeuf Op.)

Disarticulation at the Metatarsophalangeal Joint of the Second, Third, Fourth, and Fifth Toes (Fig. 87).—The disarticulation is best performed by means of the racket incision. The handle of the racket is placed over the middle of the dorsum of the phalanx and metacarpus. When this method is employed for the great and little toes, where the cicatrix is subjected to lateral pressure, the handle of the racket is placed more toward the middle line of the foot. The interno- and externoplantar flaps of Farabeuf are also designed to protect the scar from pressure. For the second, third and fourth toes the ordinary racket method, with the handle of the racket over the middle of the dorsum of the phalanx and metacarpus, is employed. The handle should be carried down beyond the level of the web before the circular incision is cut, as otherwise difficulty will be experienced in making the flaps meet.

TECHNIC.—Locate the joint line and indicate the racket incision ABCDE. Grasp the toe between the thumb and forefinger; flex strongly. Make the central dorsal incision AB. This lies over the extensor tendon and extends from above the joint line to a level below the free edge of the web. Deepen the circular incision BCDE to the bone, dorsiflex the toe, and complete the disarticulation from the plantar aspect. Preserve the glenoid ligament in the stump, avoid injuring the transverse metatarsal ligaments, attend to the hemostasis, unite the opposing tendons, and close the wound with interrupted silkworm-gut sutures. In the little toe the handle of the racket is placed more internally, so that the scar will be protected from pressure; or Farabeuf's externoplantar flap may be employed. In this method the head of the metatarsal is covered by a flap obtained largely from the external surface and partly from the plantar, the flap being folded over the head of the bone. The resulting cicatrix lies deep in the web between the fourth and fifth toes, and in this situation is well protected from lateral and terminal pressures.

Disarticulation of the Great Toe at the Interphalangeal Joint.—This operation is performed by means of a single palmar flap and corresponds to the analogous procedure in the fingers.

TECHNIC.—Locate the joint line and mark out the incision ABCDE. ABC crosses the interphalangeal joint at right angles. Flex the toe and hold it with the thumb and forefinger. Deepen the incision ABC and enter the joint, divide the lateral and glenoid ligaments, and turn the knife blade toward the tip of the toe, hugging the plantar surface of the phalanx. The result is a square-shaped flap. Suture the opposing tendons or provide new insertions for them; close the wound with interrupted silkworm-gut sutures. The resulting transverse cicatrix lies above the head of the bone.

Disarticulation of the Great Toe at the Metatarsophalangeal Joint (Figs. 87, 88).—There are several operations for disarticulation of this joint, the two best being the racket and the internoplantar flap (Farabeuf).

RACKET METHOD. Disarticulation of the great toe by the racket method differs only from the ordinary racket operation already described by the fact that the handle of the racket, instead of being placed over the middle of the dorsum of the phalanx and metatarsal, is placed more toward the middle line of the foot. In this way the resulting cicatrix is protected from lateral pressure. The glenoid ligament and the sesamoid bones are retained.

INTERNOPLANTAR FLAP (FARABEUF).—The head of the first metatarsal is covered by a flap taken from the internal and plantar aspects of the toe, the resulting cicatrix lying deep in the web between the first and second toes. In this situation it is protected from lateral and terminal pressure. The same principle is applied in amputations of the thumb, little finger, and little toe. In performing this operation the relatively large size of the head of the metatarsal must be kept in mind and the incision started above the joint line.

TECHNIC.—For descriptive purposes consider the toe as having 4 surfaces: dorsal, internal, plantar, and external. Locate the joint line, mark out the incision ABCD. The point A is slightly below the dorsum of the joint line and just internal to the tendon of the extensor proprius hallucis; the point B is close to the head of the first phalanx and represents the junction of the internal and dorsal surfaces; the point C the junction of the plantar and internal surfaces; the point D the external extremities of the digitoplantar fold. Grasp the flexed toe between the forefinger and thumb. Carry the lightly curved incision AB down the toe until the level of the neck of the phalanx is reached; then curve it over the inner surface BC until the plantar surface is attained (C). Dorsiflex the toe and carry the incision (CD) obliquely upward to the web; plantiflex the toe, drawing it away from the second toe; join the points DA. The incision is carried directly down to the bone and the extensor tendon is cut below the level of the joint. Dissect back the internal flap (ABC) to the joint line. Detach the glenoid ligament from the base of the phalanx, leaving it and the sesamoid bone in the stump. Divide the lateral ligaments and complete the disarticulation. Attend to the hemostasis. Suture the opposing tendons and close the wound with interrupted silkworm-gut sutures.

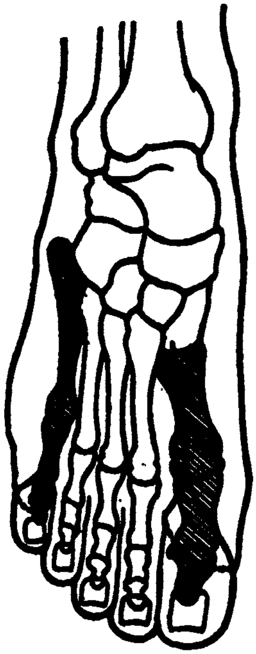


FIG. 89.—DISARTICULATION OF THE GREAT AND LITTLE TOES AT THE TARSOMETATARSAL JOINTS.

Amputation of the Great Toe with Part or All of Its Metatarsal Bone (Fig. 89).—A partial amputation through the metatarsal is preferable, especially if the attachment of the peroneus longus tendon can be saved. The amputation is best performed by the racket method. The handle of the racket is not placed over the middle of the dorsum of the metatarsal, but over the dorso-external aspect. In this way lateral pressure on the scar is avoided. If difficulty is experienced in disarticulating the base from the internal cuneiform, the upper end of the handle of the racket is curved inward from the dorsum of the foot. The circular portion of the racket crosses the plantar aspect at the level of the web, with the distal end of the handle at the joint line and the upper end over the internal cuneiform bone.

Amputations of the Outer Four Toes with Their Metatarsals (Fig. 80).—In amputation of the second, third, and fourth toes, with their corresponding metatarsals, the handle of the racket is placed over the middle of the dorsal aspect of the bone. In the little toe the upper end of the racket is curved externally from the dorsum toward the sole.

Disarticulation of All Toes.—Metatarsophalangeal disarticulation by means of equal rectangular flaps (Fig. 90) is to be preferred when possible. Dorsiflex the toes and make 5 separate circular incisions around the cutaneous bases. On the plantar aspect the incision falls in the digitoplantar crease and when completed the incisions unite in the web. Two dorsilateral incisions are made over the metatarsal of the first and fifth toes, producing 2 equal rectangular flaps. With the foot at a right angle, dissect the soft parts back to the joint line and make a high division of the extensor tendons. Secure the lateral ligament and the capsule, then the flexor tendons. Unite the flexor and extensor tendons and close the wound with interrupted silkworm-gut sutures.

AMPUTATIONS THROUGH THE FOOT

The anterior portion of the foot is broad and flat; the posterior, high and narrow. In all amputations of the foot the incision is so planned that the cicatrix does not fall on the sole. In the broad anterior portion of the foot a long plantar and a short dorsal flap are used; while in the narrow posterior portion the stirrup, racket, and internal flaps are employed. Every effort should be made to save as much of the foot as possible, and care taken to avoid disturbing the relationship of the intertarsal joints. In the treatment of amputations of the foot the pull exercised by the tendo Achillis must be taken into account and measures instituted to prevent the stump assuming the equinous position.

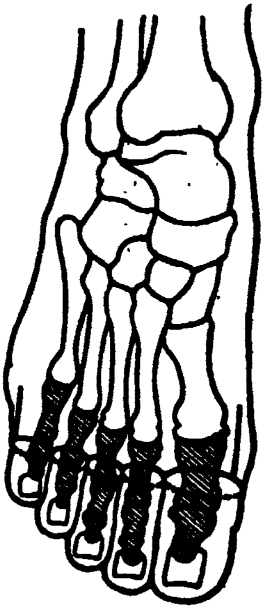


Fig. 90. Disarticulation of All the Toes at the Metatarsophalangeal Joints.

Amputation Through the Metatarsus

History. According to Fabricius Hildanus, this operation (Fig. 91) was known to the ancients. It was performed by Sharp, of London, in 1741 (Farabeuf), then by Turner, of Yarmouth, in 1778.

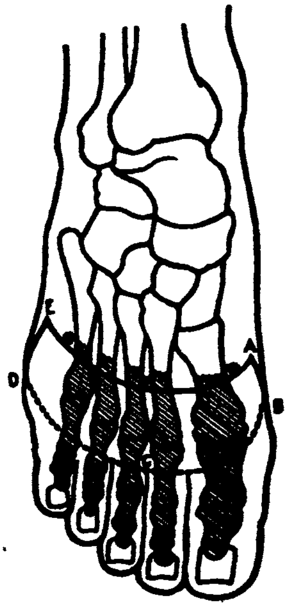


Fig. 91. — Amputation Through the Metatarsals. Dorsal view. (Sharp Op.)

Indications. The operation is to be preferred to disarticulation through the tarsometatarsal joint, as the insertions of the chief muscles of the foot are retained (tibialis posticus, peroneus longus, tibialis anticus, peroneus brevis and tertius), and movement in all directions is possible. It is indicated in cases of injury involving the bases of the toes and in gangrene following frost bite, etc.

Methods.—In the typical operation a long plantar and a short dorsal flap are used. In the atypical cases the covering is obtained from any available skin. The operation may be performed by the oblique method, in which case the lower end of the ellipse is taken from the sole.

TECHNIC.—Indicate the level of the saw line ✠ Mark out the long plantar flap ABCDE. The point A is just behind the saw line on the midlateral aspect of the inner side of the foot. The point B indicates the level of the crease between the sole and the great toe, E the crease between the sole and the little toe. The incision AB runs vertically downward, then crosses the sole BCD behind and parallel to the web to the point D, then up to E just above the saw line. The dorsal incision AFB is parallel to the plantar and 2 to 3 cm. above it. Extend the foot strongly, deepen the dorsal incision, cut the extensor tendons, and dissect up the flap for a short distance above the saw line. Retract the soft parts, divide the bones, bend the forepart of the foot sharply so that the cut ends of the bones protrude, then proceed to remove the bone from the flap, always hugging the bones and cutting against them, until the plantar flap is free. By cutting from above downward, and hugging the bone, less damage is done to the flap than in cutting the flap from below upward.

Treat the individual bones by the aperiosteal method and suture the opposing tendons over them. Close the wound with interrupted silkworm-gut sutures. The resulting cicatrix lies on the dorsum a short distance above the divided bones.

TARSOMETATARSAL AMPUTATIONS

History.—According to Ashurst, the North American Indians practiced this operation as a means of preventing their prisoners from escaping. The first recorded amputation was performed by Hey, of Leeds (1799). The first pure disarticulation was practiced by Lisfranc in 1815. Skey's modification was introduced at a somewhat later date.

Anatomical Points.—The tarsometatarsal joint forms an irregular line. The base of the second metatarsal is locked between the first and third cuneiforms and is further secured laterally to the internal cuneiform by a strong interosseous ligament. The prominence of the base of the fifth metatarsal indicates the external extremity of the joint; the junction of the internal cuneiform and the metatarsus of the great toe indicates the external extremity. If the parts are swollen, and the latter cannot be palpated, the joint will be found to lie midway between the internal malleolus and the metatarsophalangeal joint.

Indications.—This operation is inferior to an amputation through the metatarsus. In the latter the heads of the metatarsals are sawed, and with them the bony insertions of the chief muscles of the foot (tibialis anticus, posticus, peroneus, tertius, brevis, and longus). In many cases an atypical disarticulation, in which some portion or portions of the metatarsals can be preserved, is to be preferred to the typical operation. The classical amputation is indicated in frost bite, crushes of the forefoot in which the sole is healthy, and in limited diseases. On account of the relationships of the synovial sacs, this operation should not be employed in diseases involving the synovial membrane.

Methods.—These are Lisfranc's, Hey's, and Skey's. Lisfranc's method is a pure disarticulation through all the joints. Hey's method is a disarticulation through the outer 4 joints, with the removal of the projecting portions of the internal cuneiform. Skey's method is a disarticulation through the outer 3, and through the inner with a division of the base of the second metatarsus. These methods are carried out by a short dorsal and a long plantar flap.

Lisfranc's Operation (Figs. 92, 93).—"The secret of facility in the operation lies in hitting the line of the articulation." This is best done by finding the joint of the first and fifth metatarsals, the remaining joints forming a convex line between these 2 with a recess for the head of the second metatarsal, the base of which projects upward ¼ to ⅓ in. Grasp the fore part of the foot with the left hand, place the forefinger and thumb on the bases of the metatarsals of the little and great toes. Locate the joint line and cut firmly across the dorsum of the foot (ABC) to the bone. The incision is slightly convex forward and a little anterior to the joint line. Due allowance is made for the difference in the thicknesses of the inner and outer borders of the foot. Prove the position of the joint line by opening the first and fifth tarsometatarsal joints. Flex the foot strongly and mark out the long plantar flap (ADEF). This flap extends forward from the extremities of the dorsal incision along the borders of the foot, crossing the sole over the heads of the metatarsals. Put the dorsal ligaments on the stretch and, by strongly depressing the foot, complete the disarticulation. With a short, strong knife open the 3 outer joints, then the joint between the first metatarsal and the internal cuneiform, and, lastly, free the head of the second metatarsal. This is best accomplished by inserting the point between the first 2 metatarsals and moving it backward and forward until the lateral ligament is divided. Repeat this procedure between the second and third metatarsals, and then open the joint between the second metatarsal and the middle cuneiform. Put the soft parts, attached to the plantar surface

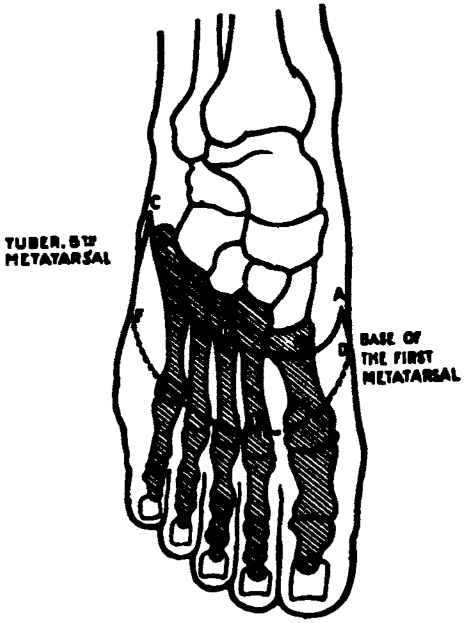


FIG. 92.—DISARTICULATION AT THE TARSOMETATARSAL JOINT. Dorsal view.

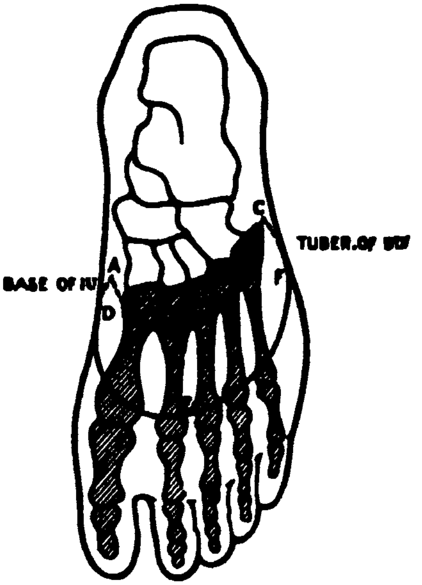


FIG. 93.—DISARTICULATION AT THE TARSOMETATARSAL JOINT. Plantar view.

of the metatarsal, on the stretch by pointing the toes backward toward the heel and pulling the heads of the metatarsals forward. The tense soft parts are detached by short strokes of the scalpel directed against the bones. Carried out in this way, the plantar flap can be cut with a minimum amount of damage to tissues and to circulation. Ligate the dorsalis pedis, the two plantar arteries with their branches. Suture the opposing tendons over the tarsus, insert small rubber tube drains at the extremities of the wound, bring the flaps together, and close the wound accurately with silkworm-gut sutures. Place the foot in a right-angle splint, flex the knee, and elevate the whole limb on a pillow. The resulting cicatrix is dorsal, and the scar will be protected from pressure owing to the retraction of the skin over the instep.

Hey's Operation.—To avoid the difficulties of disarticulating the head of the second metatarsal, Hey sawed off the projecting portion of the internal cuneiform. He employed a short dorsal flap to expose the articulation, severed the connection of the outer 4 joints, and sawed through the internal cuneiform, the amputation being completed by dissecting the bones from the plantar flap.

Skey's Operation.—Skey attempted to solve the same problem by dividing the base of the second metatarsus.

Comment.—Many surgeons prefer to cut the plantar flap before any attempt is made to disarticulate (Duval's method). The use of a dorsal flap is to be avoided, as the cicatrix will be over the edge of the sawn bone and subjected to the friction of the shoes. Estes, of Bethlehem, who has had unrivaled experience in traumatic cases, considers Hey's operation superior to Lisfranc's.

Difficulties.—(1) Mistakes in the location of the joint line. (2) Insufficient covering for the inner aspect of the internal cuneiform. (3) Difficulty in disarticulating the head of the second metatarsal. (4) Scoring of the plantar flap.

After-treatment.—As soon as the wound is healed, institute a course of massage, early movements, and weight-bearing exercises. Early functional use is to be encouraged, and the patient made to walk in an ordinary shoe, the fore part of which is filled with lamb's wool.

Disarticulation at the Mediotarsal Joint

This operation (Figs. 94, 95), which is associated with Chopart's name, was performed in 1791. It consists of the disarticulation between the astragalus and os calcis, posteriorly; and the scaphoid and cuboid, anteriorly. The method of operating is similar to Lisfranc's, a long plantar flap being used to cover the stump.

Anatomical Points.—Internally the joint line lies immediately behind the tuberosity of the scaphoid; externally midway between the tip of the external malleolus and the base of the fifth metatarsal.

Technic.—The steps of this operation are similar to Lisfranc's. Locate

the joint line; place the thumb and forefinger of the left hand on the extremities of the joint line. Mark out the slightly convex dorsal incision ABC. A dorsal flap should not be cut, as the scar would lie over the bone. The plantar flap ADEF runs along each side of the foot, and then crosses the sole a little beyond the middle of the metatarsal bones. The greater depth of the inner side of the foot necessitates a slightly longer incision on the internal side. Deepen the dorsal incision ABC to the bone, the tendons being divided with the foot at right angles. Strongly depress the dorsum of the foot, enter the astragaloscaphoid joint, then the calcaneocuboid. At the outer ends of the joint, which is concave anteriorly, the knife must be carried forward toward the toes. Continue the depression of the foot; cut the tense inferior calcaneoscaphoid and the calcaneocuboid ligaments. Complete the disarticulation by severing the plantar flap. With the foot at right angles, suture the extensor tendons to the dorsal periosteum. If necessary, complete the operation by dividing the tendo Achillis. The plantar flap is accurately sutured to the dorsal incision with silkworm-gut, and the angles of the wound drained. The stump is placed in a right-angle splint, the knee slightly flexed, and the whole elevated on a pillow.

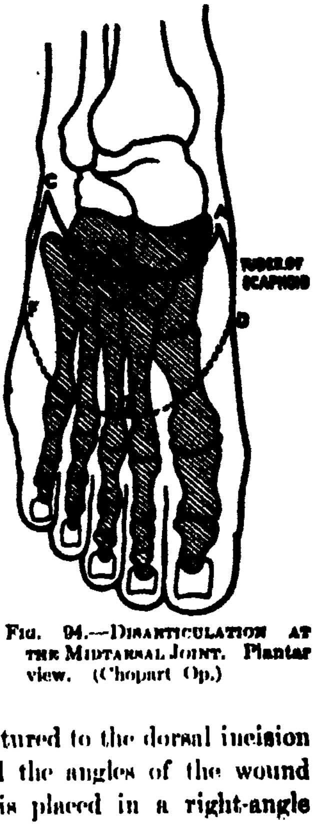


FIG. 94.—DISARTICULATION AT THE MIDTARSAL JOINT. Plantar view. (Chopart Op.)

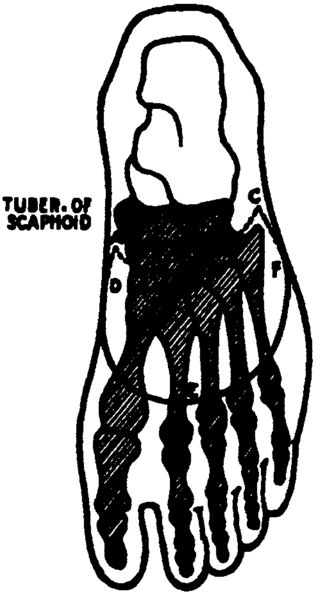


FIG. 95.—DISARTICULATION AT THE MIDTARSAL JOINT. Dorsal view. (Chopart Op.)

After-treatment.—Massage movements **and weight-bearing** exercises as soon as **the wound is healed. Encourage the patient to walk on the flat of the foot. Use an ordinary boot with a light steel in the sole, and stuffing.**

Comment.—The classical operation of Chopart involves the disarticulation of the midtarsal joint, but it is not necessary to adhere rigidly to this. The bones may be sawn through above or below the joint, according to circumstances. The practical value of Chopart's operation has been disputed on the following grounds:

1. The tendo Achillis, being unopposed by the extensor muscles, draws up the heel and forces the scar downward when it is subjected to pressure.

2. The body weight is transmitted through the astragalus to the heads of the metatarsal bones. By removing the anterior portion of the foot, the astragalus is

deprived of this resistance and tends to be thrust forward beneath the tibia against the cicatrix.

3. "Owing to the arrangements of the synovial membrane, it is unsuitable in tuberculous disease which has spread as far as the scaphoid."

The first and second of these objections can be met by suturing the extensor tendons into the dorsal periosteum. Tenotomy of the tendo Achillis is performed with the object of relieving the strain on the newly inserted extensor tendons. Without the re-insertion of the tendons, this tenotomy is only of temporary value.

The Edinburgh School strongly advocates this operation, and considers that if the extensor tendons are reinserted, and careful after-treatment carried out, Chopart's operation yields excellent and permanent results. Estes of Bethlehem confirms this opinion, and in his hands Chopart's amputation has provided useful and satisfactory stumps.

Subastragaloid Disarticulation

In this operation (Figs. 96, 97) all the bones of the foot are removed except the astragalus.

History.—According to Volpeau, subastragaloid disarticulation was proposed by Logncrolles. The elder Textor (1841) performed the first operation, Malgaine followed in 1845, Semon in 1848. Farabeuf developed his method in 1871.

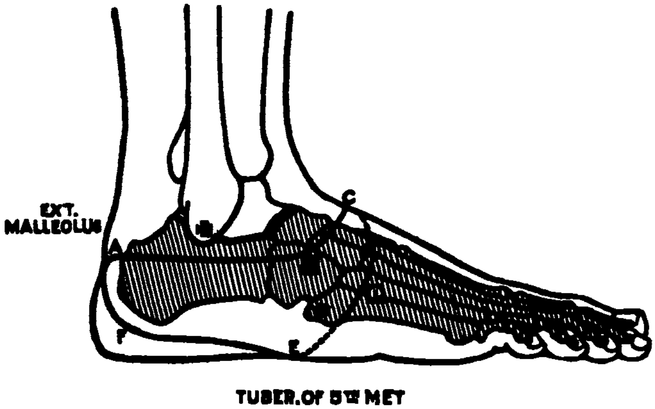


Fig. 96.—Subastragaloid Disarticulation. External view. (Farabeuf Op.)

Methods.—The two best methods are the internal plantar flap of Farabeuf and the external racket of Kocher.

Internal Plantar Flap (Farabeuf).—Farabeuf's operation is to be preferred, if the conditions of the soft parts warrant its employment. Although apparently complicated, the disarticulation can be performed with ease and rapidity. We have no hesitation in saying that in the cadaver it is technically much easier to perform than any of the other methods. Kocher's external racket has a simple incision and conserves the soft parts, but the actual disarticulation is more difficult than Farabeuf's. Bayer, of Germany, and J. Hutchinson, Jr., are strong advocates of subastragaloid disarticulation. Hutchinson claims it has the following advantages over Syme's amputation:

The stump is 10 cm. (4 in.) longer, and has a broader base support with a thicker pad at the end; a better arterial supply subjected to less risk of damage during the operation; and the artificial foot can be more satisfactorily fitted.

TECHNIC.—Locate the external malleolus, the tuberosity of the fifth metatarsal, the joint between the cuneiform and the scaphoid, the tendon of the extensor proprius hallucis, the external tuberosity of the os calcis, and the outer border of the tendo Achillis, where it is inserted into the os calcis. The incision ABCDEF commences at the junction of the external border of the tendo Achillis with the os calcis A, runs horizontally forward a thumb's breadth below the external malleolus to the level of the tuberosity of the fifth metatarsal B, then curves sharply inward, passing over the dorsum just in front of the scaphocuneiform joints to the tendon of the extensor proprius hallucis C. It then descends on the inner side of the foot to the center of the sole D. From D it slopes backward to a point slightly behind the base of the fifth metatarsal E. From here it passes horizontally backward just above the outer border of the sole to the external tuberosity of the os calcis F, then upward to the start of the incision A. Seize the front of the foot with the left hand, depress it, and rotate inward. Commence the incision over the course of the tendon of the extensor proprius hallucis at a point just in front of the scaphocuneiform joint C, carry it down to the bone and outward 5 cm. (2 in.) toward the base of the fifth metatarsal to the point B, then backward a thumb's breadth below the external malleolus to the junction of the outer border of the tendo Achillis with the os calcis A. Raise the foot, rotate outward, deepen the incision CD, and continue over the inner border of the foot just in front of the joint between the internal cuneiform and the first metatarsal to the center of the sole D. From D extend the incision outward to the point E, behind the base of the fifth metatarsal, where it turns backward to the external tuberosity of the os calcis F. The incision which is parallel to the sole finally turns upward to the point A. The incision is deepened to the bone throughout. Divide the tendons and raise the short upper and outer flap ABC until the head of the astragalus is exposed; render the head prominent and enter the astragaloscaphoid joint. Divide the interosseous ligament between the astragalus and os calcis, the remaining calcaneo-astragaloid ligaments, and the tendo Achillis just above its insertion.

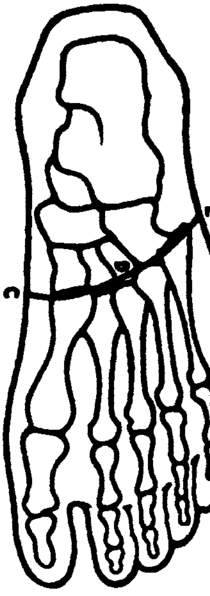


FIG. 97.—SUBASTRAGALOID DISARTICULATION. Plantar view. (Farabeuf Op.)

The amputation is now completed by shelling out the os calcis from the internal flap. The irregularities of the internal surface of the os calcis make this the most difficult part of the operation, and great care must be exercised to avoid injuring the nerves and vessels in the flap. This danger is best overcome by using the point of a very short resection knife and directing it against the bone, not toward the flap. Ligate the dorsalis pedis and the 2 plantar arteries, shorten the nerves, secure and suture the opposing tendons. Bring the flap together over the head of the astragalus and suture with silkworm-gut. Drainage is best attained by a stab wound in the posterior aspect of the stump. If the incision be carried too obliquely backward, a portion of the head will have to be removed. The bandages should be applied so that a moderately firm pressure will be exerted over the end of the stump. Flex the knee and elevate the limb on a pillow.

Kocher's External Racket.—The following description is taken from Kocher (54):

> "A racket-shaped incision is made, the handle being placed horizontally, immediately behind and below the tip of the external malleolus and the circular incision carried round the foot at the level of Chopart's joint. The incision is somewhat similar to that of Perrin and Chauvel, and is closely allied to Farabeuf's internal plantar flap. The joint between the astragalus and scaphoid is opened from the dorsum without opening the calcaneocuboid joint. A narrow knife is then passed backward and slightly upward beneath the head of the astragalus so as to divide the strong interosseous ligaments between it and the os calcis. The soft parts are then dissected from the os calcis, first from the upper surface, then from its outer and under surfaces, and lastly from its inner and posterior surfaces. The greatest difficulty is met with at the inner side in clearing the projecting sustentaculum tali. If the soft parts are insufficient, the projecting head of the os calcis may be sawed off. The astragalus fits well into the heel cap. The stump bears weight excellently."

DISARTICULATION AT THE ANKLE JOINT

History.—The circular method of disarticulation was first performed by Brasdor (1774), and later modified by Sabatier, Velpeau, and Gunther. J. Bell (1805) used an anterior flap; Kluge, employing a similar flap, sawed off the malleoli. Double lateral flaps were used by Rossi and Blandin; antero-internal flaps by Jobert and Lering; internal flaps by Soupart, Sédillot, and Guerin; external flaps by Baudins and Soupart. Syme performed his heel flap operation in 1842, Pirogoff his osteoplastic in 1852, A. Moschcowitz his osteoplastic in 1904.

Surgical Anatomy.—The joint is represented by a transverse line crossing the front of the leg about 1.3 cm. (½ in.) above the tip of the internal malleolus. The external malleolus descends 2 cm. (4/5 in.) below, and is 1.3 cm. (½ in.) posterior to the internal malleolus. The skin of the heel flap is nourished by the external calcaneal branches of the posterior peroneal and by the internal calcaneal of the external plantar.

Methods.—Pirogoff's osteoplastic, Syme's heel flap, Moschcowitz's osteoplastic modifications of Syme's, Farabeuf's large internal flap.

Provided conditions are suitable, Pirogoff's operation yields the most ser-

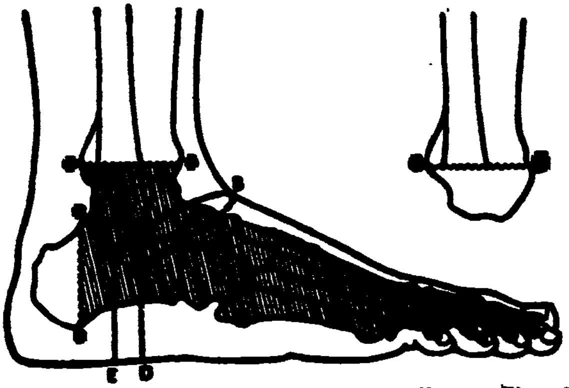


FIG. 98.—OSTEOPLASTIC DISARTICULATION OF THE FOOT. (Pirogoff Op.)

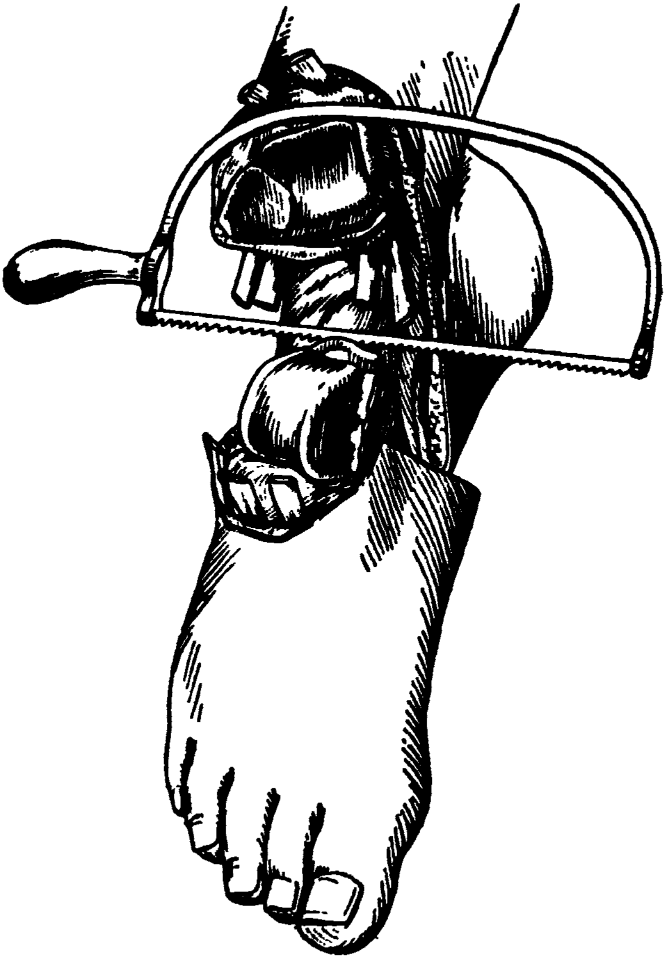


FIG. 99.—PIROGOFF'S AMPUTATION. The ankle joint has been opened and the section of the os calcis begun. (Schmieden).

viceable stump. Moschcowitz's method is superior to the methods of Syme and Farabeuf.

Pirogoff's Osteoplastic Amputation (1852) (Figs. 98, 99, 100).—This is an osteoplastic amputation at the ankle joint, by means of a heel flap in which the posterior portion of the os calcis is retained and applied to the sawn surface of the tibia and fibula. Pirogoff's operation was the first osteoplastic amputation. Contrary to what most writers have claimed, Pirogoff attached only a secondary importance to the osteoplastic feature, his main endeavor being to devise a procedure which would overcome the difficulties encountered in dissecting out the os calcis. The Pirogoff stump is superior to Syme's. It is longer, permits of an early functional use, has little or no tendency to atrophy, is not painful, and as the origin and insertion of the gastrocnemius are both intact, the combined movements of the knee and ankle make running and other exercises possible. It is not difficult to fit with an artificial foot. We have used an ordinary walking shoe with a sling strap and found it perfectly satisfactory. It has been urged against this operation that it is difficult to perform; that it is unsuitable in diseased conditions; that the os calcis sometimes fails to unite, and that necrosis is apt to occur.

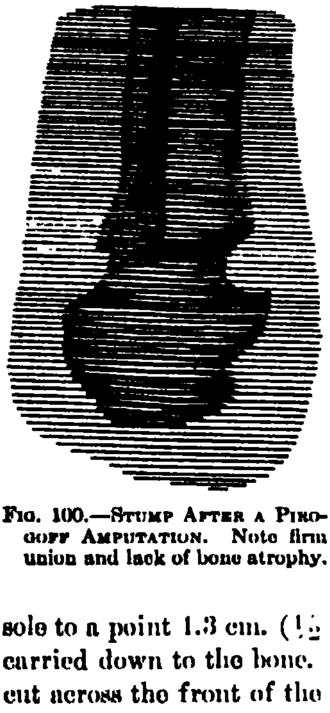


FIG. 100.—STUMP AFTER A PIROGOFF AMPUTATION. Note firm union and lack of bone atrophy.

TECHNIC.—As preliminary to the operation a tenotomy of the tendo Achillis is made. Locate the joint line, hold the foot at right angles to the leg, and outline the stirrup incision ABCDE. The incision commences at the tip of the external malleolus A, passes downward and directly across the sole to a point 1.3 cm. (½ in.) below the internal malleolus C. This incision is carried down to the bone. The points A and C are then joined by a transverse cut across the front of the ankle ABC. These 2 incisions are at right angles to each other. The dorsal flap ABC, with the severed extensor tendons, is retracted upward and the capsule of the ankle joint divided. Extend the foot and divide the lateral ligaments. Avoid injuring the posterior tibial artery. Cut the posterior ligament of the ankle joint at its insertion into the astragalus. Locate the astragaloid articular surface, saw through the os calcis immediately behind this joint, and remove the foot. The direction of the saw corresponds to the stump incision. Retract both flaps upward and expose the tibia and fibula to a level above the articular surface of the tibia, apply the saw, divide the bones at right angles. Ligate the tibialis, anterior peroneal, and the malleolars. Bring the sawn surface in accurate apposition and suture. Apply a terminal pressure dressing and a posterior splint. Flex the knee and place the limb on a pillow.

AFTER-TREATMENT.—Early functional use is to be encouraged; an ordinary shoe with a sling strap can be worn.

MODIFICATION OF PIROGOFF'S AMPUTATION. In order to prevent the tilting of the os calcis, Gunther, Sédillot, Schede, and Volkmann sawed the os calcis obliquely; V. Bruns, Brems, Busk, Pasquier, and Lefort sawed it horizontally—V. Bruns and Boekel in a curved direction; Tower and v. Eiselsberg made sagittal section; Quimby, a vertical section, which he placed between the retained malleoli. The advocates of the horizontal section claim that the skin of the sole bears pressure better than the thin skin of the heel. All these methods have the disadvantage that a portion of the scar lies on the under surface of the foot. The original Pirogoff operation is superior to these modifications because the scar is free from pressure, the skin of the heel bears weight readily and soon becomes as thick as that of the sole. The tuberosity of the os calcis, having a separate ossification center, is not so often affected with tuberculous disease; it also frequently escapes in traumatic crushes of the front of the foot. Kocher and Bier adhere to the original Pirogoff as being superior to the modifications. We hold the same belief. Figures 101 and 102 show some of the modifications that have been proposed.

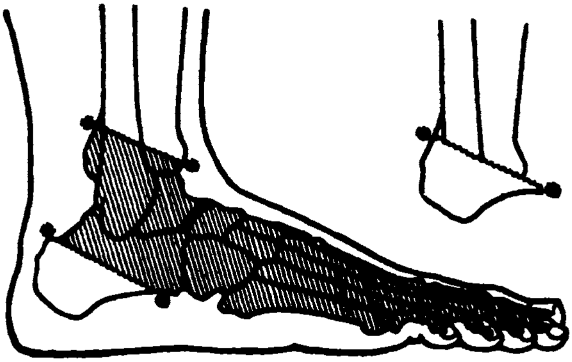


FIG. 101. OSTEOPLASTIC DISARTICULATION OF THE FOOT. Gunther's modification of Pirogoff's amputation.

Syme's Heel Flap Amputation (1842) (Fig. 103). The tibia and fibula are divided just above the bases of the malleoli and the flap is obtained from the integument of the heel. The stump bears weight well, and the portions of the bone likely to be infected in the disease are removed.

TECHNIC. Locate the joint line, hold the foot at right angles, and trace the stirrup incision BCDE. Place the left hand behind the heel, with the thumb and forefinger at the points A and C. A is the tip of the external malleolus, C the point exactly opposite—not the internal malleolus, but a point considerably below and behind it. With a short strong knife cut down to the bone across the sole and join the 2 points A and C. The plane of the incision AEDC is vertical, or if the heel be prominent it slopes slightly backward. Ex-

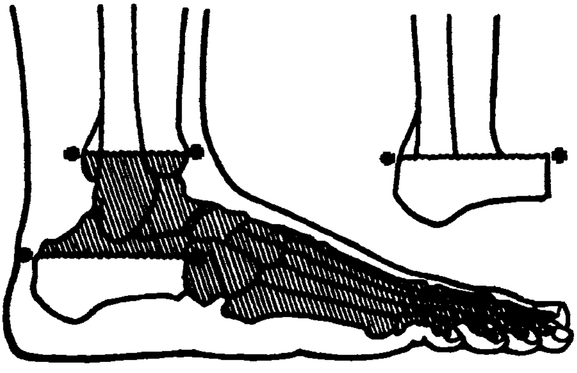


FIG. 102.—OSTEOPLASTIC DISARTICULATION OF THE FOOT. Pasquier-le Fort modification of Pirogoff's amputation.

tend the foot and join the extremities of the stirrup A and C by an incision ABC running straight across the front of the ankle. Dissect up the posterior flap from the os calcis, keeping the edge of the knife close to the bone until the posterior border of the calcaneum is freed. Open the ankle joint from the front, divide the lateral ligaments extending between the malleoli and astragalus, and complete the removal of the foot by severing the tendo Achillis. Retract the flaps upward and free the tissue to the saw line X. When cutting behind the tibia, care must be exercised to prevent the wounding of the posterior tibial vessels. The saw is applied at the base of the external malleolus; the plane of section being made at right angles to the long axis of the limb and a thin slice of the tibia removed. Ligate the tibial, peroneal, and malleolar vessels and secure the opposing tendons. Bring the cut-shaped heel flap over the sawn end of the bone and unite with interrupted silkworm-gut sutures. Drain by stab wound in the heel flap. Apply a terminal compression dressing and bandage, place the limb in a posterior gutter splint, and elevate the whole on a pillow.

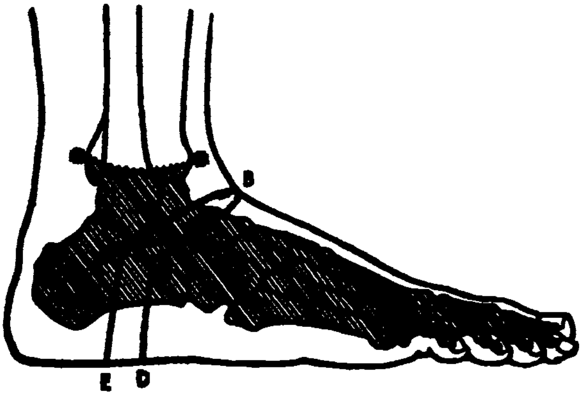


FIG 103.—AMPUTATION THROUGH THE MALLEOLI. (Syme operation.)

AFTER-TREATMENT.—As soon as the wound is healed, begin massage, muscular movements, and weight-bearing exercises, encouraging early functional use.

Comment.—Commencing the internal incision at the interior malleolus renders the flap unsymmetrical, unduly long and increases the difficulty and dangers of the dissection. Sloughing of the flap from scoring and wounding of the blood supply and collection of blood and serum in the cup-shaped heel flap may occur.

Moschcowitz's Osteoplastic Amputation at the Ankle Joint (Figs. 104, 105).—This is an osteoplastic modification of Syme's amputation at the ankle joint. The following is Moschcowitz's description (65):

> At the very outset I would state that in the following remarks I shall not discuss those amputations in which a portion of the os calcis or astragalus can be preserved. No one who has had any experience with the Pirogoff amputation or with any one of its numerous modifications will, or can, deny that the ultimate results are simply ideal and, to my mind at least, there can be no discussion or improvement when an amputation of this nature can be performed. This operation, therefore, should be the operation of choice in all those cases in which the disease or trauma, for which

the amputation is performed, lies distally to the tibiotarsal articulation, provided always, of course, that the os calcis is healthy and that there is sufficient integument to cover the stump. There occur, however, a number of cases in which the provisions above stated do not exist, and recourse must be had either to an amputation higher up on the leg, or, in a few rarer instances, to the so-called Syme's amputation. It is particularly of this latter class that I wish to speak, as I believe I have devised a method which, while preserving all the good qualities of the Syme method, excludes all of its drawbacks and disadvantages. The cutaneous incision is made in such a manner and such a place that we can obtain ample healthy skin for covering the stump; if there is any choice, it is preferable, of course, to carry the incision in such a manner that the resulting cicatrix will not come to lie directly on the end of the stump; and of these two, preferably anteriorly, because then the integument covering the stump will be formed out of the thick heavy skin forming the heel; but on no account should the length of the stump be sacrificed for the heel flap. After retraction of the skin there follows a rapid exarticulation of the foot at the ankle joint; this exposes the two malleoli and the contiguous portion of the tibia covered by its cartilage. An irregular octahedral-shaped piece of bone is now sawn out of the fibula in the following manner: The saw enters the fibula on the inner side, approximately on the level of the cartilage covering the tibia, and is carried obliquely upward and outward for a distance of about one and a half centimeters to within one or two millimeters of the external surface of the fibula; the saw is now withdrawn and made to enter the external surface of the fibula; also at the level of the cartilage covering the tibia, and is then carried mainly upward, but with a slight deviation inward, until it meets the end of the first saw-cut, thereby preparing a small osteoperiosteal flap from the outer surface of the fibula, which can be readily fractured and deflected temporarily outward. The portion of bone removed has the shape of an irregular octahedron; one apex of this is at the tip of the malleolus, the other one is at the junction of the two sawn surfaces, while the two lateral borders are on the external and internal surfaces

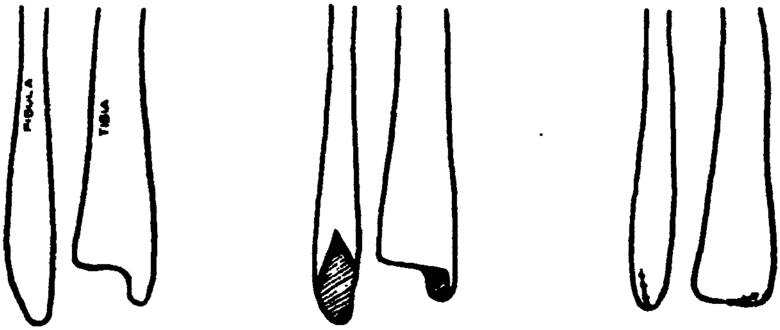


FIG. 104.—METHOD OF TREATING THE BONE IN MOSCHCOWITZ OSTEOPLASTIC AMPUTATION OF ANKLE.

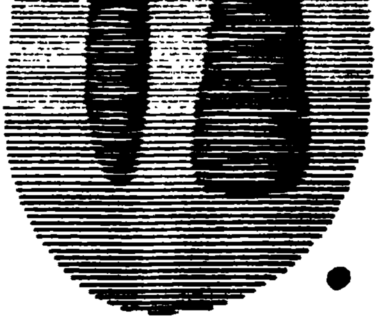


FIG. 105.—RESULT OF MOSCHCOWITZ OPERATION. Well-rounded, well-nourished, painless stump.

of the fibula, on a level with the cartilage covering the tibia. The two sawed surfaces are now approximated and fastened by catgut sutures, which pass through the periosteum covering the parts.

"We now turn our attention to the tibia. As is well known, the internal malleolus is shorter and thicker; the procedure has to be varied somewhat therefore. The saw enters the inferior surface of the malleolus about two millimeters from its internal surface, and is carried in an upward direction to the level of the cartilage covering the tibia; this forms a small osteoperiosteal flap from the inner surface of the malleolus, which is temporarily deflected inward. The remaining portion of the malleolus is now removed with a saw, also on a level with the cartilaginous surface. The two sawn surfaces are now approximated and held in place by means of catgut sutures, which pass through the periosteum covering the parts. The final step consists of accurate hemostasis, followed by suturing of the skin, after the introduction of suitable drainage, if indicated."

AMPUTATIONS OF THE LEG

History.—Bier's original method (1891) was subsequently simplified by Gluck (1894), improved by Bunge (1898), still further improved by Bier (1898), Payr (1898), and Bunge (1899). Duval and Laborie originally used the tendinoplastic method. Wilms (1902) revised and extended its use. For aperiosteal method, see pages 269, 343. Franke (1913) introduced his osteoplastic intracondyloid amputation of the leg.

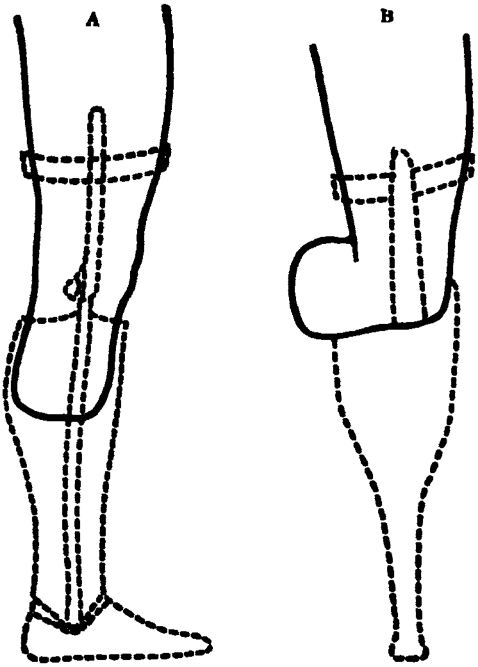


FIG. 106.—AMPUTATION AT THE "SITE OF ELECTION." A, Wearing an artificial limb. B, Wearing a peg leg. (Veau.)

Site of Election (Fig. 106).—In the pre-Listerian days, when the majority of wounds were expected to suppurate, it was exceptional to obtain an end-bearing stump. In amputations performed between the ankle and tubercle of the tibia it was the practice to rest the anterior surface of the flexed knee on an artificial limb, while the stump projected behind. A long, projecting stump being an inconvenience, the amputation was always performed at the site of election, that is, one hand's breadth below the knee. It is needless to say that this wasteful method has long since been discarded, as under present conditions a useful stump may be obtained at any level.

Methods.—Modern investigation shows that the production of a useful stump does not depend on the kind of flap, but directly on the treatment of the bone. If the aperiosteal, tendinoplastic or the osteoplastic methods be used, it does not matter where the covering comes from, provided the soft parts are sutured without tension and the cicatrix does not fall directly over the end of the stump. Even this last precaution is not an absolute necessity, for the aperiosteal method is said to yield a weight-bearing stump even in the face of an infected wound. The most universally applicable method is the oblique circular. The flap is taken from the anterior external surface and should equal 1½ times the diameter of the limb at the line of bone section. Bier uses a large tongue-shaped anterior flap. If unequal flaps are used, the longer one is taken from the extensor surface and the shorter one from the flexor. The longer flap should equal the diameter of the limb at the level of the bone section. Teale's rectangular flap method is wasteful and involves a high section of the bone. A short stump with a movable knee-joint is, from the standpoint of the elasticity of gait, preferable to a disarticulation at the knee joint. When the relative values of a high amputation and a disarticulation are considered, it will be seen that in a high amputation, provided the knee joint is movable, the stump allows of a much more elastic gait.

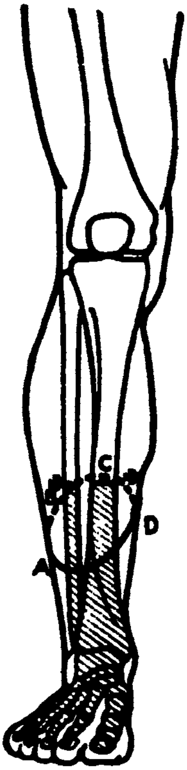


FIG. 107.—AMPUTATION THROUGH THE MIDDLE OF THE LEG BY AN OBLIQUE CIRCULAR INCISION.

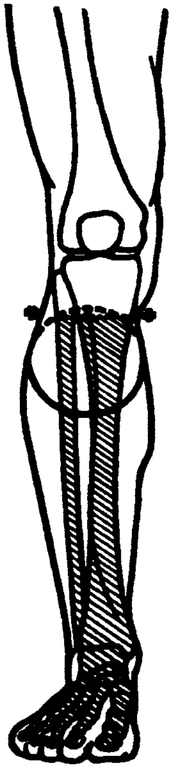


FIG. 108.—AMPUTATION BELOW THE KNEE. Oblique circular.

Aperiosteal Amputation of the Leg (Figs. 107, 108). We consider this the safest and best operation for the average case. It can be performed by the oblique circular, single or double flap methods. The simplest and most universally applicable method is the oblique circular. The longer flap is taken from the anterior surface at the ankle and consists of skin and fascia. In the middle third there is no muscle on the inner surface of the tibia and to protect the skin from pressure of the spine of the tibia it is usual to take the flap from the anterior external surface.

TECHNIC. Locate the line of bone section X. Mark out the oval incision ABCD, the distance AC corresponding to 1½ times the diameter of the leg at the point X. Dissect up the flap as far as the end of the incision, cut the muscle transversely, divide the interosseous membrane, and hold back the soft parts with a 3-tailed muslin retractor. Divide the periosteum by a circular incision, push it downward for a distance of 1 cm. Saw through at X, leaving 1 cm. of bare bone. Scoop out the medullary canal for a similar distance. Before the bones are divided, rotate the leg inward and saw the tibia and fibula at the point X. Then shorten up the fibula, removing 1 to 2 cm. The anterior surface of the tibia should be beveled by cutting out a short wedge of bone (Fig. 28) or rounded off with the bone forceps (Fig. 29). In the region of the upper and lower epiphysis Kocher's method of sawing the bone convexly is employed.

HEMOSTASIS.—The anterior tibial vessels will be found in the interosseous membrane; the posterior tibial between the deep and superficial muscles; the peroneal vessels in the lower 2/3 of the leg behind the fibula. The nerve trunks in the long flap are dissected out and divided above the weight-bearing level. The cicatrix lies on the postero-internal aspect above the bone section.

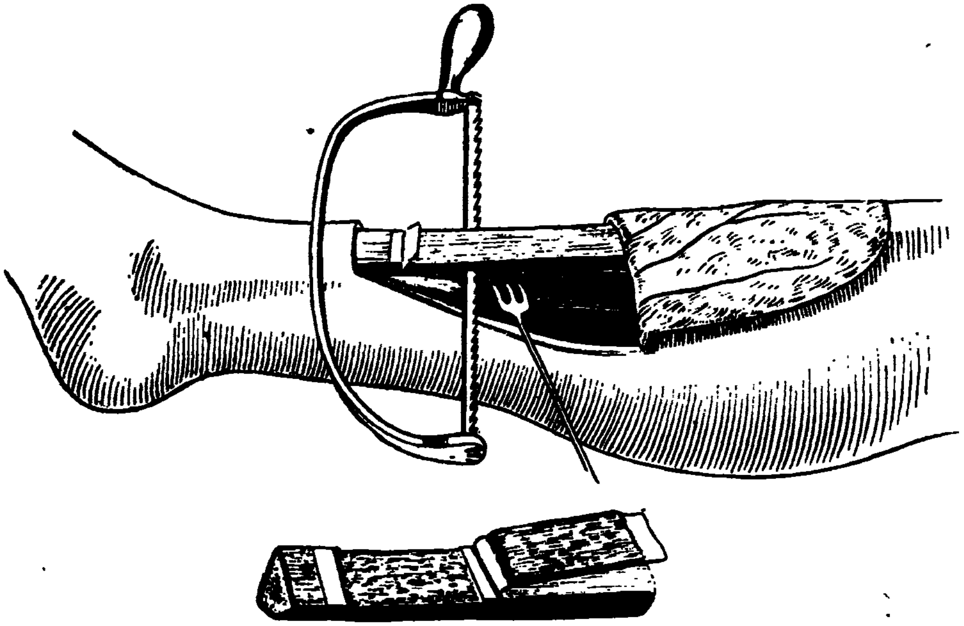
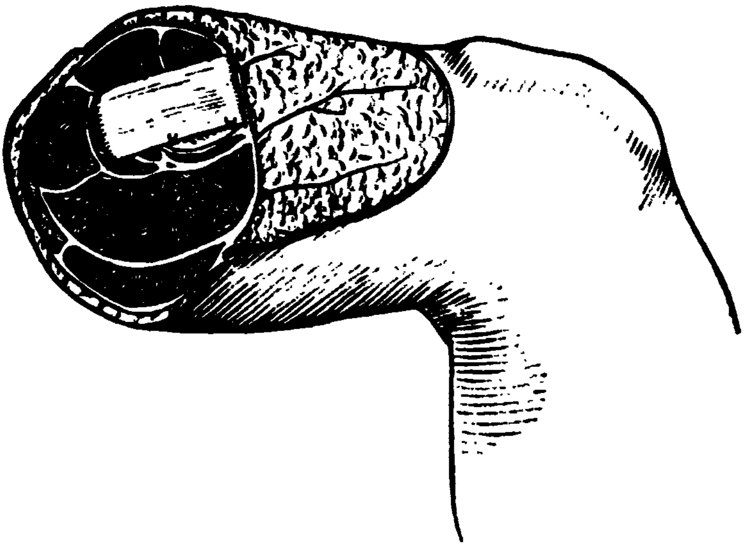


FIG. 109.—BIER'S OSTEOPLASTIC AMPUTATION OF THE LEG. First stage: a flap of bone is sawn off with the frame saw. The inset represents the periosteal flap and the line of amputation. (Schmieden.)

AFTER-TREATMENT.—As soon as the wound is healed, Hirsch's medico-mechanical technic is employed (see Prevention of Stump Atrophy, page 272).

Tendinoplastic Amputation (Duval-Wilms) (Fig. 19).—This is applicable in the lower third of the limb. The bones are rounded off and the stump of the tendo Achillis is firmly sutured over the end of the bone. This simple method yields a serviceable stump.

Osteoplastic Amputation (Bier, 1891) (Figs. 109, 110, 111).—Ideal conditions and some practice are necessary to obtain a successful result by this method. It should not be used in traumatic cases or in the face of infection. The following is taken from von Schmieden's admirable description of Bier's osteoplastic amputation of the leg:



o. 110.—Bier's Osteoplastic Amputation of the Leg. Second stage: the sawn surfaces of the tibia and fibula are covered by the osteoplastic flap. (Schmieden.)

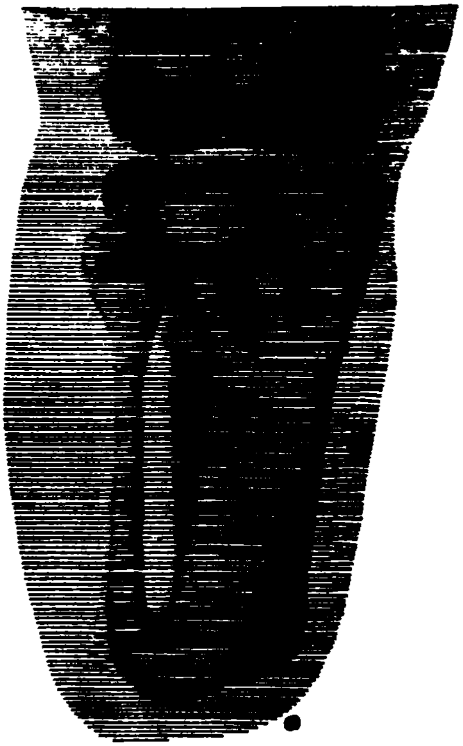


Fig. 111.—Result of Bier's Osteoplastic Amputation of the Leg.

"A large tongue-shaped flap is used, the apex of the flap lying on the tibia. The flap is lifted up as far as the site of the amputation, care being taken to preserve the periosteum covering the tibia. Now make two linear incisions in the periosteum at the anterior and inner borders of the tibia. Incise the periosteum across at the lower angle of the wound, raise it a little way in the form of a flap, and apply the saw at the base of the flap. Fix the narrow blade slantwise in the frame, thus enabling the saw to run parallel to the surface of the bone. A fine plate of bone is sawn off, levered up with an elevator and turned back. Separate up the periosteum still further, thus providing it with a pedicle which, though freely movable, will afford sufficient nourishment to the flap. The entire limb is now removed along the line as indicated. A circular incision is first made, the tissues between the bones are divided and finally both bones are sawed through evenly and at the same level and their edges rounded off. Attend to the vessels and nerves in the cross section. If the bony flap is now reflected over the sawn surface of the tibia it will cover both tibia and fibula. It is fixed in this position by passing a few sutures through the distal flap of the periosteum. Finally cover the sawn surface with the large skin flap. The scar lies at the back of the leg. Bier's stump is an excellent one and soon becomes capable of bearing the direct weight of the body."

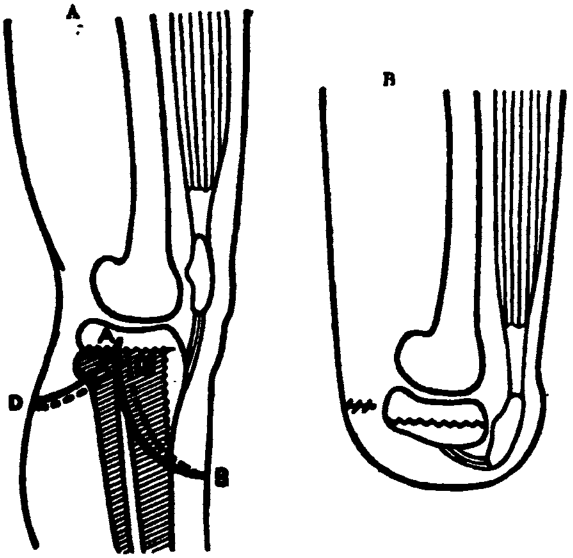


FIG. 112.—OSTEOPLASTIC INTRACONDYLOID AMPUTATION OF THE LEG. A, Showing flaps and line of bone section. B, Resulting stump; the bone flap which includes the tibial tuberosity is applied to the sawn surface of the tibia. (Franke Op.)

AFTER-TREATMENT.—The stump should be placed on a posterior splint and the whole elevated. As soon as the wound is healed, Hirsch's treatment is started, page 272.

Osteoplastic Intracondyloid Amputation of the Leg (Franke Operation) (Fig. 112).—This amputation is an application of the osteoplastic principle to Larrey's intracondyloid method. The following account is adapted from Franke (36):

TECHNIC.—(1) Cut a large anterior flap (ABC) extending laterally somewhat posterior to the median axis of the knee and 3 to 4 cm. below the tuberosity of the tibia, and a smaller posterior flap (ADC) extending 6 to 8 cm. below the joint line. (2) Reflect the pretibial integument to the tuberosity of the tibia. With a Helferich saw cut a bone plate including the tibial tuberosity. Carry the saw upward to within 1 to 1½ cm. of the joint line, then forward through the root of the bone plate to the periosteum. Free the anterior flap

containing the bone plate. (3) Put the flexors on a stretch and divide them below the joint line. (4) After treating the nerves and blood-vessels, turn the anterior flap upward so that the sawed surface of the osseous plate is applied to that of the tibia. Suture in place.

Comment.—The knee joint must be free from disease and the upper portion of the tibia sound. The following advantages are claimed: The joint is not opened, the flap is short and well nourished; there is little damage to the muscles; the cicatrix is removed from terminal pressure; the method yields a good end-bearing stump; the technic is comparatively easy.

DISARTICULATION AT THE KNEE

Anatomical Points.—The skin over the anterior aspect of the knee is loose, coarse, tough, and well supplied with blood. The subcutaneous tissues are scanty. The soft parts in front of the joint are largely dependent on the integrity of the prepatellar anastomosis formed by the anastomica magna, the articular branches of the popliteal, and the anterior recurrent tibial. The popliteal artery extends on the back of the knee from the inner side of the femur to the level of the tibial tubercle. It crosses the mid-point of the joint line and lies on the joint capsule. In the popliteal space it is closely covered by the vein and nerve, the interior popliteal nerve being posterior and somewhat external to the vein.

The landmarks of the knee joint are the condyles of the femur, the adductor tubercle, the tuberosities and tubercles of the tibia, the head of the fibula and patella. With the leg extended, the joint line lies 2 cm. (4/5 in.) above the tibial tubercle, that is, slightly above the apex of the patella. In semiflexion the line corresponds to the upper border of the external tuberosity of the tibia. The adductor tubercle at the upper back part of the internal condyle marks the epiphyseal line. The head of the fibula is on the outer aspect somewhat posteriorly, and its upper border is slightly above the level of the tibial tubercle. Anteriorly the synovial membrane extends 5 to 6 cm. (1 to 1 1/5 in.) above the joint, internally 7.5 cm. (1½ in.).

History.—Amputation of the knee joint was mentioned by Hippocrates, B. C. 430, and was performed by Fabricius Hildanus at Düsseldorf in 1581. Isolated cases were reported by Petit, Hoen, and Brasdor. It was first performed in America by Nathan Smith in 1824. In 1830 Velpeau performed his first disarticulation and became an enthusiastic advocate of this procedure. Stephen Smith introduced his method of modified lateral flaps in 1852.

Indications.—A slightly distal amputation is preferred to a disarticulation, provided the muscular and ligamentous attachments to the tibia and fibula are preserved. A short stump with a movable knee joint gives a more elastic gait.

On the other hand, disarticulation, when feasible, is preferable to the transcondyloid and supracondyloid operations. In the absence of infection disarticulation yields an ideal stump. In the pre-antiseptic days this condition was rarely obtained and the difficulties and dangers attendant on the infection of the synovial pouches were so grave (mortality 75 per cent.) that the operation was in ill repute. Thomas M. Markoe did much to dispel this impression, and today these objections are valueless. It is stated that a patient cannot wear an artificial limb so comfortably or so naturally as when a transcondyloid or supracondyloid operation is done, because the artificial joint is below the normal one, and although it is not noticeable on standing it is unmistakable when sitting. Figure 113 demonstrates clearly that it is possible to fit an artificial limb in such a manner that it is hard to detect any difference between the knees when the patient is seated. Such esthetic objections should be treated for what they are worth; and it must be borne in mind that, after the preservation of life, the goal of all amputations is to provide a useful, comfortable stump. Disarticulation, properly performed, fulfils this need with more certainty than amputations through or above the condyles. It is indicated if the joint is in a healthy state and sufficient skin can be obtained to cover the broad condyles, in senile gangrene, gunshot wounds, and malignant growths of the bones of the leg, etc. The weak point in the disarticulation of the knee joint is the amount of skin necessary to cover the large condyles. In a series of 20 cases Habs reported 5 with gangrene of the flap. This shows the necessity of retaining the patella in order to preserve the prepatellar anastomosis.

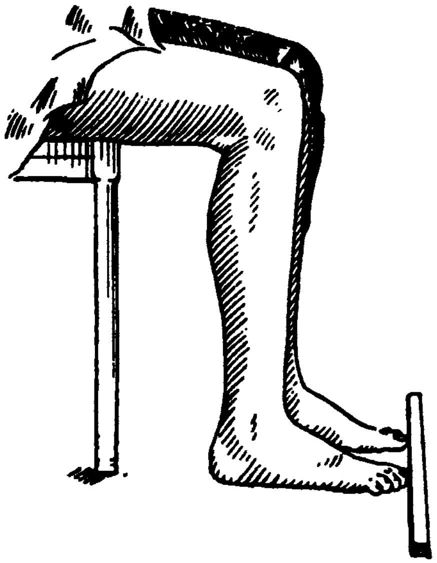


FIG. 113.—PATIENT WEARING AN ARTIFICIAL LIMB FOR A DISARTICULATION AT THE KNEE JOINT. Note how little, in this posture, the artificial limb projects beyond the normal.

Methods.—The best methods are the bilateral hooded flaps of Stephen Smith and the oblique circular of Bauden. Others are the long anterior flap (Nathan Smith) and Miller's circular method.

Disarticulation of Knee by Means of Bilateral Hooded Flaps (Fig. 114).—This method was introduced by Stephen Smith in 1852. (No better amputation was ever devised.—EDITOR.) According to Smith, the operation is performed as follows:

"The incision ABCDE is commenced one inch (4 cm.), A, below the tubercle of the tibia, and carried downward and forward over the most prominent part of the side of the leg; B, until it reaches the under surface when it curves toward the median line C. When that point is reached it is continued directly upward to the center of the articulation D. A second incision begins at the same point, AEC, as the first and pursues a similar direction upon the opposite side of the leg and meets it in the median line on the posterior part. The following precautions should be remembered: The incision should incline moderately forward down to the curve of the side of the leg, to secure ample covering for the condyles; and that upon the interior aspect should have additional fullness for the purpose of insuring the sufficient flap for the interior condyle. In the dissection, the skin, fascia and cellular tissue are raised and the ligament of the patella divided, allowing the patella to remain.”

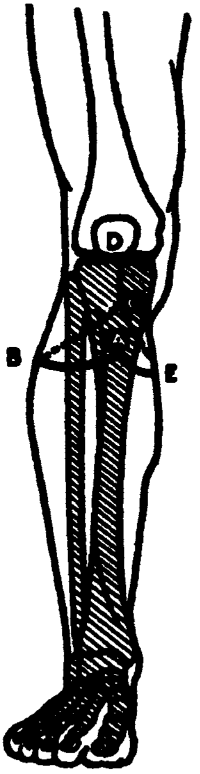


FIG. 114.—DISARTICULATION AT THE KNEE BY MEANS OF BILATERAL HOODED FLAPS. (Stephen Smith Op.)

At this junction the knee is flexed and the knife is inserted between the tuberosities of the tibia and the semilunar cartilages. These latter are left in contact with the condyles of the femur. The crucial ligaments are severed and disarticulation completed by cutting through the soft parts. The retention of the semilunar cartilage to form a cap for the femur was advocated by Brenton in 1872. Ligate the popliteal vessels, isolate the internal popliteal nerve, and excise 5 cm. (2 in.). Unite the flaps with interrupted silkworm gut, insert a small rubber drainage tube in the upper angle of the wound. The resulting vertical cicatrix is drawn up between the condyles. Apply a posterior splint, raise the whole on a pillow, and steady the stump with sand bags.

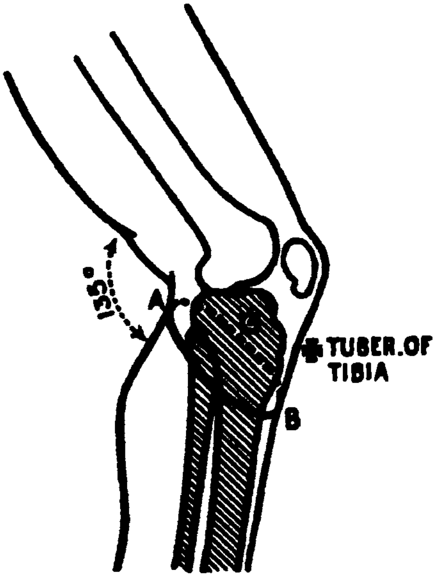


FIG. 115.—DISARTICULATION AT THE KNEE. Oblique circular. (Bauden Op.)

AFTER-TREATMENT. As soon as the wound is healed begin massage, motion, and weight-bearing exercises. Functional use should be established within 3 weeks.

Disarticulation of Knee by the Oblique Circular Method (Bauden's Elliptical) (Fig. 115).—The knee is bent at an angle of 135°. An anterior flap ABC begins behind the joint line and extends 4 fingers' breadth below the tubercle of the tibia. In the half bent condition of the knee the incision is in the continuation of the long axis of the thigh. Dissect up the skin and fascia, flex the knee, sever the patellar ligament, detach the semilunar cartilages

from the tibia, divide the crucial, lateral, and posterior ligaments, and complete the disarticulation by making a transverse section of the soft parts. The skin cicatrix is entirely on the posterior surface.

Comment.—As the blood supply of the anterior flap depends largely on the prepatellar anastomosis, the patella is retained. Due allowance must also be made for the contraction of the hamstring muscles.

Disarticulation by the Long Anterior Flap (Nathan Smith).—In this method the recurrent tibial artery is cut and, as the flap receives a large portion of its nutrition from this artery, it is liable to slough.

AMPUTATIONS IMMEDIATELY ABOVE THE KNEE-JOINT

Methods.—(1) Transcondyloid femorotibial osteoplastic (Ssabanejoff), (2) transcondyloid (Carden-Buchanan), (3) supracondyloid femoropatellar osteoplastic (Stokes-Gritti), (4) transcondyloid or supracondyloid tendinoplastic (Wilms).

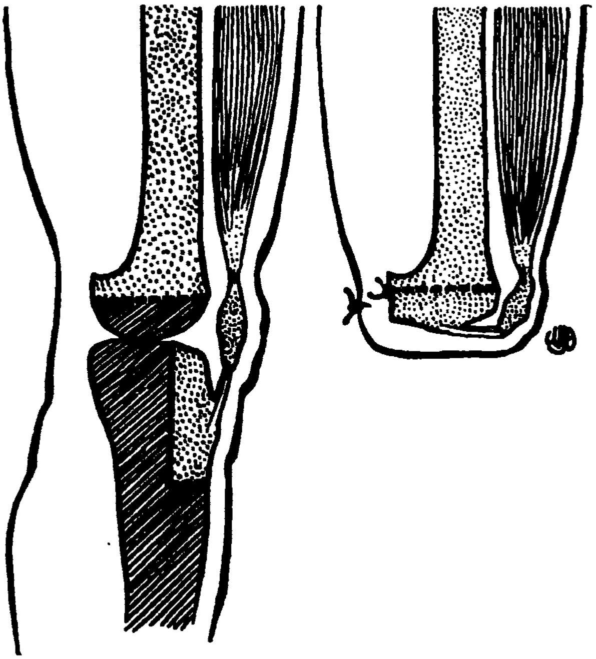


Fig. 116.—Ssabanejeff's Transcondyloid, Femorotibial Osteoplastic Amputation of the Femur.

Indications.—The supra- and transcondyloid amputations of the femur are superior to amputations through the lower third of the thigh. They are less serious procedures, as the limb is divided at a lower level, where there is little else than skin, tendons, and bone, and the few blood-vessels are readily controlled. The medullary canal is unopened and there is little tendency to bone protrusion or osteophytic outgrowth. The stump is longer and better suited to withstand pressure. The abductors of the thigh remaining practically intact, the stump is capable of controlling the movements of an artificial limb. When the patella can be retained Stokes's modification of Gritti's osteoplastic is used; if the patella has to be sacrificed, one of the modifications of Carden's transcondyloid or the tendinoplastic method is employed.

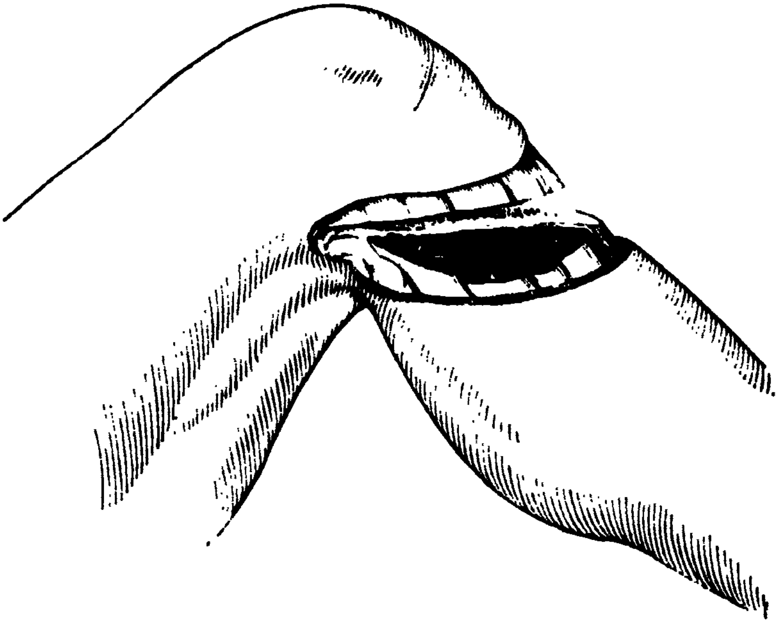


Fig. 117.—Osteoplastic Amputation Through the Condyles of the Femur. (Ssabanejeff Op.) An oblique circular incision has been made, and the oblique section of the tibia begun.

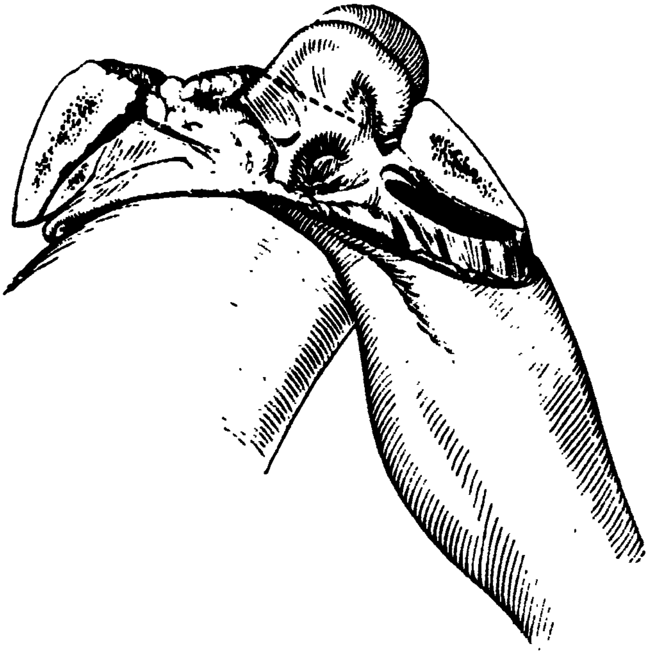


Fig. 118.—The Flap Containing the Bone Removed from the Tibia Thrown Backward, the Condyles Cleared and the Line of Bone Section indicated by the Dotted Line. (Ssabanejeff Op.)

If the upper end of the tibia and the knee joint are free from disease, Ssabanejeff's osteoplastic amputation is of value.

(1) **Ssabanejeff's Transcondyloid, Femorotibial, Osteoplastic Amputation of the Femur (1887)** (Figs. 116, 117, 118).—The operation is to be considered when the knee joint is healthy and a portion of the head of the tibia is available. It was originally performed by means of a long anterior and a short posterior flap, the anterior flap containing the piece of bone sawn from the tibia. The flaps are similar to those of Gritti-Stokes, but the base lies lower and the apex crosses the crest of the tibia 3 fingers' breadth below the tibial tubercle. The length of the flap equals the diameter of the femoral condyle. In the original operation the posterior flap was dissected up, the joint opened from behind, and the portion of the tibia removed by sawing from above downward. The method was unsatisfactory and led to many technical modifications. Of these Djelitizin-Kocher is the simplest and best.

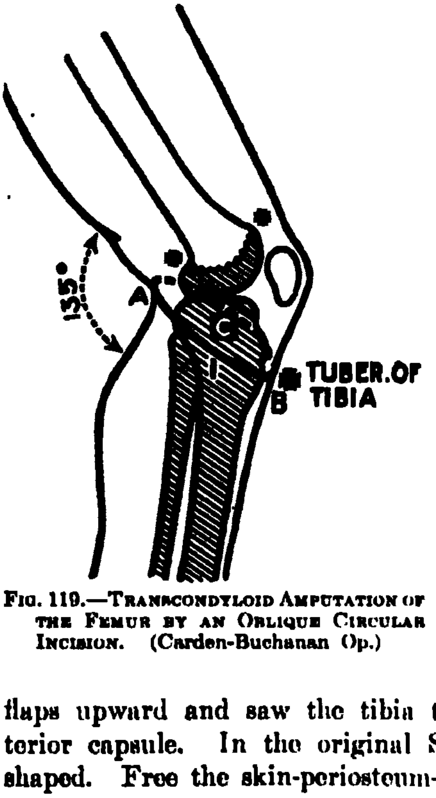


FIG. 119.—TRANSCONDYLOID AMPUTATION OF THE FEMUR BY AN OBLIQUE CIRCULAR INCISION. (Carden-Buchanan Op.)

TECHNIC (DJELITIZIN-KOCHER).—Djelitizin (1895) sawed the tibia obliquely from below upward instead of vertically from above downward. Construct an anterior flap similar to Carden's by the oblique circular method. Retract the flaps upward and saw the tibia through in a concave manner to the posterior capsule. In the original Ssabanejeff the piece of bone was wedge-shaped. Free the skin-periosteum-bone flap, turn it back up over the femur, clear the transcondyloid line and saw through the condyles from above downward and backward. The sawn surface must be convex to fit that of the tibia. Divide the remaining soft parts at the level of the joint line. Fit the concave bone flap over the convexly sawn surface of the femur. Secure the periosteal edges with interrupted catgut sutures. The remaining steps are the same as in a Carden. Bier takes his skin flap from wherever he can obtain it, and uses a thin slice of bone from the inner aspect of the tibia, maintaining that the shape of the bone, whether flat, round, or wedge-shaped, is immaterial. He also holds that the patella, on account of its being a sesamoid bone, does not stand pressure as well as a bone flap from the tibia.

COMMENT.—Definite indications are hard to lay down. In usefulness this procedure is between a Carden and a Gritti. The stump gives a better functional result than a Carden, but more skin and bone are required for it than for a Carden or a

Gritti. It is contra-indicated in face of general disease, as arteriosclerosis, diabetes, nephritis, etc.

TREATMENT.—All supra- and transcondyloid stumps are to be treated by the Hirsch method (page 272). In the osteoplastic amputations the patient should be able to use his artificial limb in from 4 to 6 weeks.

(2) Transcondyloid Amputation of the Femur (Carden-Buchanan) (Fig. 119). —Originally the operation was performed by a large anterior flap and the bone section was horizontal. The method yielded an excellent weight-bearing stump, but unfortunately the anterior flap had a tendency to slough. This led Lister (1883) to modify the incision by employing two shorter flaps. Kocher advocated the rounding of the diaphysis; Wilms the covering of cut bone by the tendon of the quadriceps extensor.

LISTER'S MODIFICATION OF CARDEN'S TRANSCONDYLOID AMPUTATION OF THE FEMUR (Fig. 120).—The following account is taken from Lister's description (58):

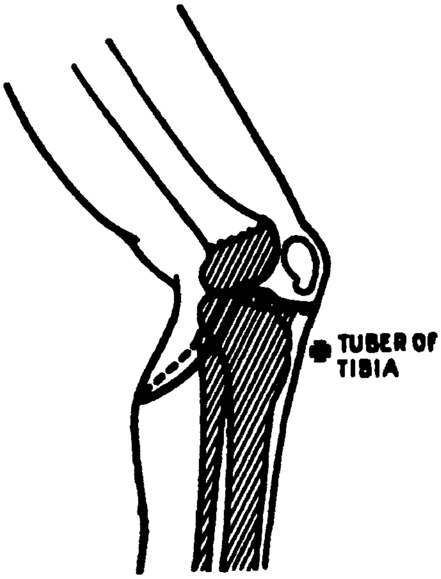


Fig. 120.—Lister's Modification of Carden's Transcondyloid Amputation of the Femur.

"The only objection to Carden's operation, as described by him, is the occasional occurrence of more or less sloughing of the long anterior flap of skin, in spite of faultless operating. It is plain that the risk of sloughing would be diminished if the flap could be made shorter by not carrying the horns of the incision, by which it is formed, so high up the limb. On making experiments on the dead body several years ago, to ascertain to what extent this could be done without disadvantage, I found that it is by no means difficult, when the parts are in their natural condition, to accomplish the operation without making any anterior flap at all, the integuments in front being divided transversely at the level of the lower end of Mr. Carden's flap. I also found it advantageous to form a short posterior skin-flap, both for the sake of coaptation of the cutaneous margins without puckering, and as a useful addition to the covering for the end of the stump. With this modification, the operation is performed as follows: The surgeon first cuts transversely across the front of the limb from side to side at the level of the anterior tuberosity of the tibia, and joins the horns of this incision posteriorly by carrying the knife at an angle of forty-five degrees to the axis of the leg through the skin and fat. The limb being elevated, he dissects up the posterior skin flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue; and, dividing the hamstrings as soon as they are exposed and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks his knife through the insertion of the quadriceps extensor, and, having cleared the bone immediately above the articular cartilage and holding the limb horizontal, he applies

the saw vertically and at the same time transversely to the axis of the limb (not of the bone) so as to ensure a horizontal surface for the patient to rest on. The popliteal artery and vein are then secured, and any articular or other small branches that may require it. When the soft parts are thickened and condensed by inflammation, the integuments cannot well be reflected above the patella with such incisions of the skin. The difficulty may be got over, however, by cutting into the joint as soon as the ligamentum patellæ is exposed, and at once removing the leg by dividing the ligaments and hamstrings. After this the soft parts can be retracted from the femur sufficiently to permit the application of the saw. The arteries having then been secured, the patella is dissected out at leisure. As thus performed, Carden's operation takes a little more time and pains than when the integument is divided in the form of an anterior flap; but these are well rewarded by the ample covering for the bone, the small external wound and the perfect security against sloughing."

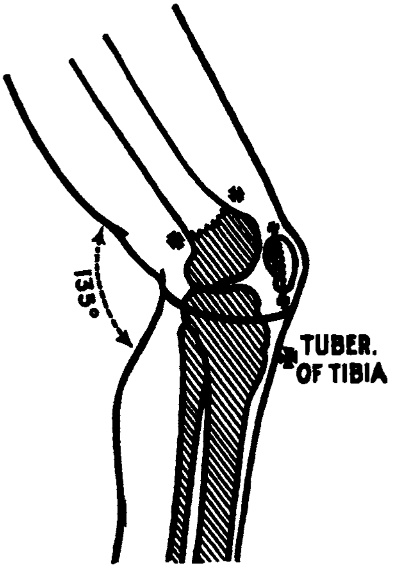


FIG. 121A.—SUPRACONDYLOID FEMOROPATELLAR OSTEOPLASTIC AMPUTATION OF THE FEMUR BY AN OBLIQUE CIRCULAR INCISION. (Gritti-Stokes Op.)

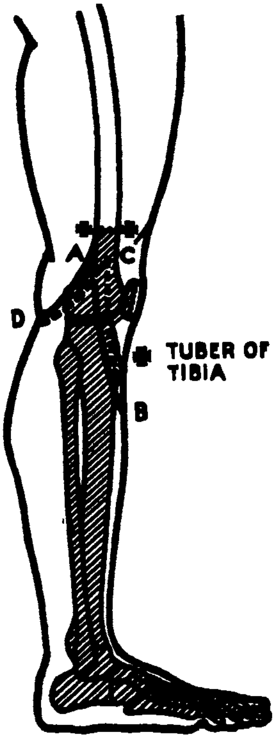


FIG. 121B.—SUPRACONDYLOID FEMOROPATELLAR OSTEOPLASTIC AMPUTATION OF THE FEMUR. By long anterior and short posterior flaps. (Gritti-Stokes Op.)

OTHER MODIFICATIONS.—*Kocher* uses the oblique circular method and saws through the condyle in a plane parallel to the articular surface, thus leaving a convex diaphyseal stump. He places his anterior flap somewhat to the inner side so that, when the abductors pull the femur inward and upward, it will not press against the inner corner of the wound.

Buchanan, in amputating in children, employed a method similar to Carden's, i. e. he separated the lower epiphysis of the femur.

(3) Supracondyloid Femoropatellar Osteoplastic Amputation (Stokes-Gritti) (Figs. 121A, 121B, 122).—This is a supracondyloid amputation of the femur with an osteoplastic covering derived by splitting the patella, the operation being performed by means of a long anterior and a short posterior flap. Gritti's original operation (1851) was a transcondyloid in which the section of the femur was made through the condyles. The split patella was an inadequate covering for this broad surface and considerable trouble was experienced in making the patella fit into place. This difficulty led Stokes (1870) to advise that the femur be divided at a level above the condyles. At this level an accurate adjustment of the sawn surface can be readily made. Stokes's modification is to be employed in preference to a true Gritti.

TECHNIC.—Locate the level of the bone section X 1 in. above the base of the condyles. Mark out the anterior rectangle flap ABC; the points A, B, and C being just above the base of the external and internal condyles; the point B being slightly below the tubercle of the tibia. The posterior flap ADC is ⅓ the length of the anterior. Raise the anterior flap ABC, cut the patellar ligament, open the joint, divide the capsule and raise the patella with the flap. Divide the posterior tendons; raise the posterior flap to the line of bone section. Clear the bone, retract the soft parts and saw through the bone. Retract the anterior flap over the end of the femur and force the posterior surface of the patella out of the wound. With a thin saw remove the articular cartilage from the posterior surface of the patella. Turn back the anterior flap and stitch the stump of the ligamentum patellae to the periosteum on the back of the femur. Attend to the hemostasis and treat the stump in the usual manner. The scar lies posteriorly.

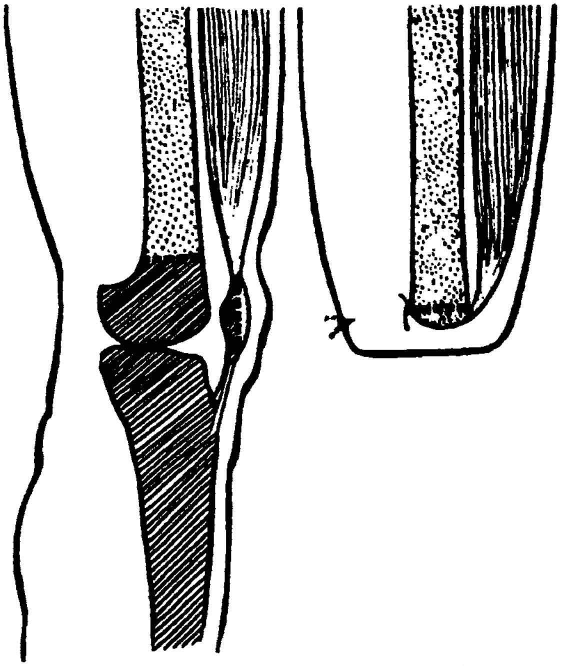


FIG. 122.—SUPRACONDYLOID FEMOROPATELLAR OSTEOPLASTIC AMPUTATION OF THE FEMUR. (Gritti-Stokes Op.)

COMMENT.—The Stokes-Gritti amputation yields an excellent end-bearing stump which will support the whole weight of the body. The medullary canal is not opened, the muscular attachments are but little disturbed and retraction of the extensor tendon is prevented. The possibility of delayed union, tilting of the fragments, the formation of osteophytes from an insufficient bony covering and the possibility of necrosis of the patella must be kept in mind. Kocher uses an oblique circular incision, saws the surface of the femur convexly, and the patella concavely.

(4) Transcondyloid or Supracondyloid Tendinoplastic (Wilms).—Wilms, after sawing through the lower end of the femur, covers it with quadriceps ex tensor tendon. The tendon is freed from the patella and sutured to the periosteum of the posterior surface of the femur. This prevents retraction of the extensor muscles and yields an excellent weight-bearing stump with a mobile skin flap.

AMPUTATION THROUGH THE THIGH

Anatomical Points.—The muscles of the thigh do not retract equally, the extensor and abductor groups retracting much less than the hamstrings. In the lower third of the thigh the main vessels lie posteriorly; in the middle third, internally; and in the upper third, anteriorly. In forming flaps or amputating by transfixion, these relations have to be remembered in order to avoid slitting the vessels. When the leg is held up in cutting the flap, the relaxed muscles, if unsupported, sag toward the posterior aspect. This sagging must be prevented or allowed for; otherwise there will be an excess of tissue in the posterior flap.

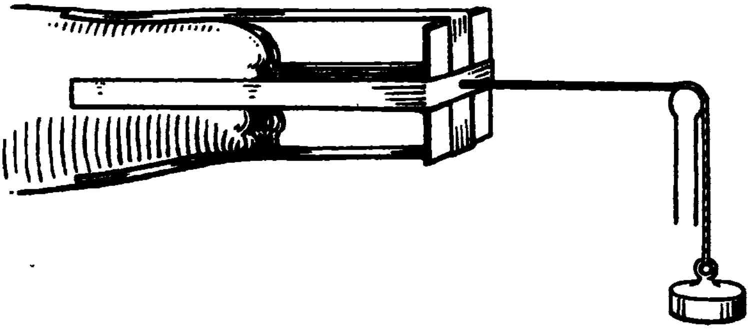


FIG. 123.—EXTENSION APPLIED TO THE SOFT PARTS TO PREVENT RETRACTION. Applicable in cases which have become infected, or which have been treated by the open method.

Methods.—The methods of amputation of the thigh are the long extensor and short flexor flaps, the circular and the racket. That of the long extensor and short flexor flaps is the best for amputations in the middle and lower third of the thigh, the racket the best for the upper third. The unequal retraction of the muscles in both the oblique and circular methods practically leads to the formation of unequal flaps. A terminal scar is to be avoided if there is hope of obtaining an end-bearing stump, toward which object correct treatment of the bone is the most important feature. Although the aperiosteal method is the one of choice, good results are also obtained in the lower third by the tendinoplastic method, and, in suitable cases, by the osteoplastic method. If the condition of the parts does not permit of closure, light traction will prevent the retraction of the muscles (Fig. 123).

Amputation Through the Middle or Lower Third of Thigh by Long Extensor and Short Flexor Flaps.—TECHNIC (Fig. 124).—Indicate the line of bone section X, mark out the U-shaped extensor flap (anterior) ABC, its length and breadth being equal to the diameter of the limb at the line of the bone section; and the flexor flap (posterior) ADC, being ½ this length. If there is much muscle, only the skin and fascia are dissected back, and the muscle cut through transversely. If the muscle tissue is scant, the quadriceps is taken in the anterior flap. The main vessels will be in the posterior flap. The bone is cleared, sawn across and treated according to the aperiosteal method (see page 269). Attend to hemostasis, expose the sciatic nerve, and treat its stump according to the Bier or Bardenheuer method. Stitch the opposing muscles and unite the fascia over them. Close the skin with interrupted sutures, inserting drainage if indicated.

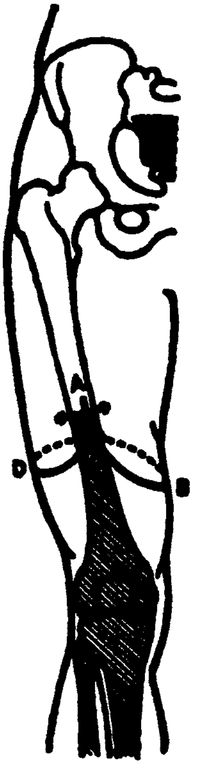


Fig. 124.—Amputation Through the Middle of the Femur by a Long Antero-internal Flap and a Convex-posterior Flap.

Amputation in the Upper Third of the Thigh (Fig. 125).—If a high amputation is performed, the artificial limb must take its chief support from the pelvis, not from the stump. The main object is to obtain a stump that can control the artificial limb. A selective racket incision is used and the bone treated by the aperiosteal method. By placing the handle of the racket on the outer side of the thigh, the bone can be readily exposed.

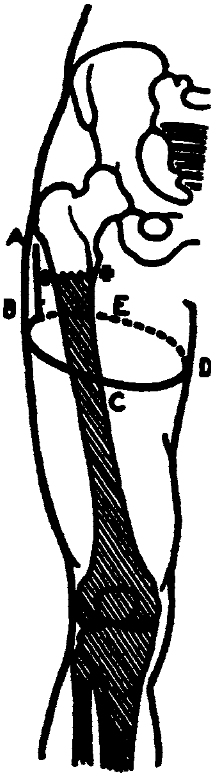


Fig. 125.—Amputation of the Femur Below the Trochanters by an External Racket Incision.

TECHNIC.—Render the limb bloodless and control the circulation by an Esmarch tourniquet (see page 277). Indicate the level of the bone section X. Mark out the racket incision ABCDE. The handle of the racket begins over the prominent external surface of the trochanter A, descends on the outer aspect of the thigh parallel to the posterior border of the vastus externus for a distance of 15 cm. (6 in.) to B. The body of the racket is represented by an oblique circular incision BCDE, the point C lying about 5 cm. (2 in.) below B. Dissect up the skin and fascia over BCD for a distance of 5 cm. (2 in.), deepen the incision AB to the bone, and free the latter. By a circular incision divide the muscles at the level of the retracted skin. Treat the stump aperiosteally, attend to hemostasis, treat the nerves in the usual manner, suture the divided muscles and fascia, and close the skin with interrupted sutures. The scar is terminolateral. With the racket incision the hemorrhage is readily controlled, and, if the operator does not care to use an Esmarch tourniquet, an assistant can seize the soft parts and control the vessels with his fingers, or with a Lynn-Thomas forceps (see page 282).

After-treatment in Amputation of the Thigh.—A dressing is applied, the

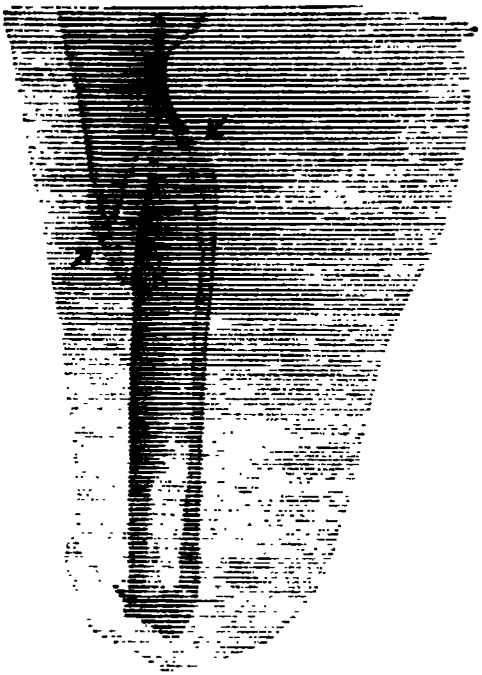


Fig. 126.—Fracture in the Stump of a Subperiosteal Amputation of the Femur. Note the spicules of bone, result of the subperiosteal amputation. The patient being unable to bear weight on the stump end, bone atrophy soon developed, with the result that a light trauma fractured the bone. Contrast with aperiosteal amputation.

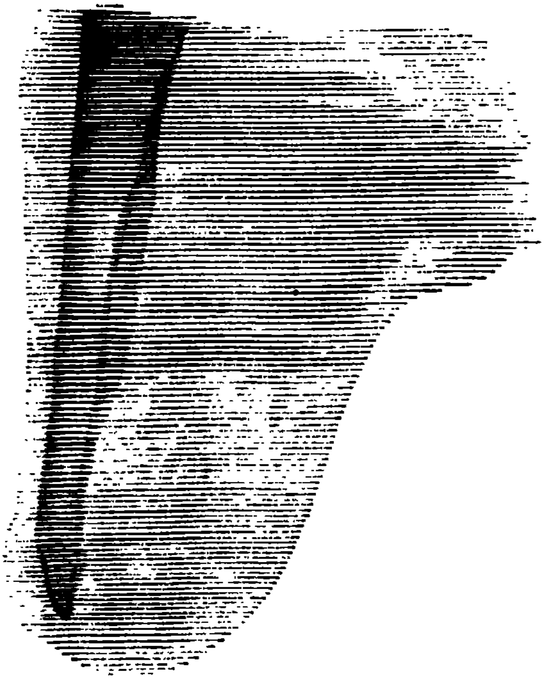


Fig. 127.—A Painful, Atrophic, Conical Stump, the Result of a Subperiosteal Amputation of the Femur.

stump bandaged to a splint, and the whole elevated on a pillow. As soon as the wound heals, Hirsch's exercises are begun, and early functional use is encouraged.

Comment.—Under the older methods of bone treatment, the results of amputations through the diaphysis were notoriously bad, an end-bearing stump being a rare exception. Cramer stated that out of 90 cases of amputations through the diaphysis of the thigh, 70 stumps were bad and only 2 were capable of bearing weight. Examples of such cases can be seen in Figures 126, 127, and 128. By employing the aperiosteal, osteoplastic or tendinoplastic amputations, good weight-bearing stumps can be obtained. Figure 129 shows the result 1 year after an aperiosteal amputation of the thigh in a man 64 years of age. He has a perfect end-bearing functional stump. Figure 130 shows the result of an osteoplastic amputation through the thigh.

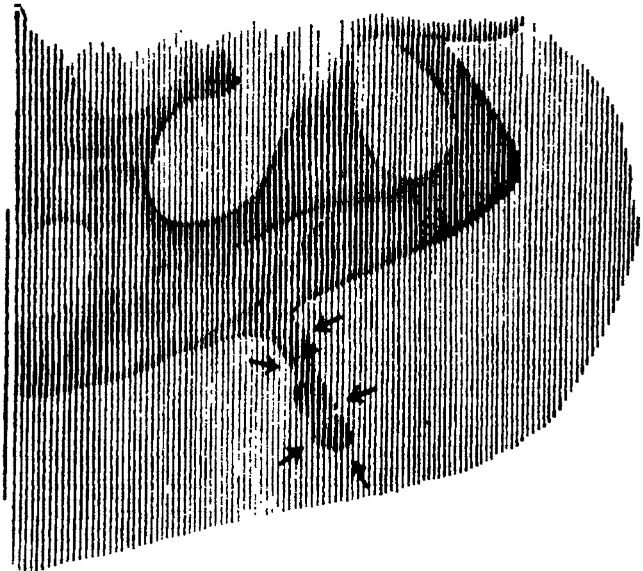


FIG. 128.—PAINFUL STUMP AFTER A SUBPERIOSTEAL DISARTICULATION OF THE HIP. Note the bony spicule. This case was diagnosed as a painful neuroma.

DISARTICULATION OF THE HIP

History.—Ravaton (1743) proposed to perform this operation by the external racket method, but was restrained by the other consulting surgeons on the case. The first disarticulation of the hip was performed by La Croix of Orleans in 1748 (Barbet), the second by Perault of St. Maure, Touraine, in 1748 (Sabatier). Both of these operations were carried out through dead tissues and can hardly be called formal disarticulations. The credit of performing a disarticulation through living tissues is due to H. Thomson of London. He performed this operation prior to 1777 (Ashurst). Kerr of Northampton employed the oval method (1795). The first recorded case in military practice was that of Larrey (1793). In America this operation was performed by Walter Brashear, of Bardstown, Kentucky, in 1806. He disarticulated by the amputation-resection method, employing an external racket incision.

Indications.—Disarticulation of the hip is indicated in cases of injury, as from gunshot wounds, severe and extensive crushing of the limb, growths of the femur, severe infection of the bone or soft parts, and spreading gangrene after failure of excision of the hip for tuberculous disease where the chronic suppuration is leading to waxy degeneration of the viscera.

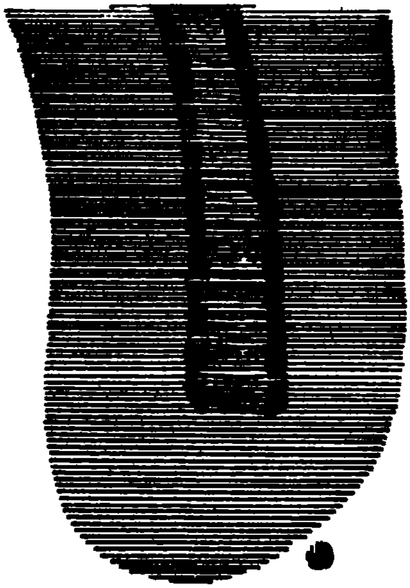


FIG. 129.—RESULT OF AN APERIOSTEAL AMPUTATION OF THE FEMUR IN A MAN 64 YEARS OLD. Note smoothness of stump, absence of bone spicules and of bone atrophy. The patient was able to bear his whole weight on the stump at the end of 4 weeks.

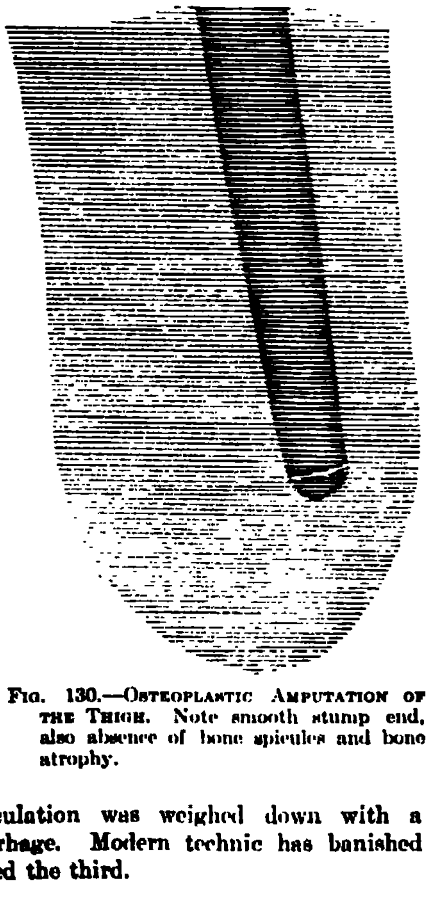


FIG. 130.—OSTEOPLASTIC AMPUTATION OF THE THIGH. Note smooth stump end, also absence of bone spicules and bone atrophy.

Dangers.—In pre-Listerian days disarticulation was weighed down with a trinity of risks: infection, shock, and hemorrhage. Modern technic has banished the former, diminished the second and controlled the third.

The possibility of secondary infection is to be guarded against by removing the wound as far as possible from the anal and perineal regions. Shock is best prevented by a careful hemostasis; a low division of the limb; blocking of the nerve trunks with novocain before their division; and supporting the blood pressure by mechanical and therapeutic means, as elevation of the foot of the table, bandaging of the extremities, application of heat, proctoclysis by the drip method, intravenous saline infusions, blood transfusion, judicious use of morphin, and the selection of the proper anesthetic. The hemorrhage is best controlled by expelling as much blood as possible from the limb, which is done by elevating it for 5 minutes, or by the application of an Esmarch compression bandage, or by placing the patient in the Trendelenburg position. The further entrance of blood in the part to be amputated is prevented by the application of an elastic tourniquet at the root of the hip, by the ligation of the main vessels at an early stage in the operation, by retaining the tourniquet until the main vessels are ligated, by the use of the Lynn-Thomas forceps tourniquet and, in selected cases and under definite precautions, by Momburg's constrictor. If the operator employs the dissection method, ligating every vessel encountered, the amputation may be performed without these blood-saving devices.

Methods Used in Controlling Hemorrhage.—See also Hemostasis, page 277.

1. Preliminary ligation of the external iliac artery.

2. Temporary digital or mechanical control of the iliac artery through an abdominal incision (McBurney).

3. Preliminary ligation or temporary compression through a special incision, as the first step in the anterior racket operation.

4. The Esmarch tourniquet. The drawback in the use of this tourniquet in amputation of the hip is its tendency to slip. In order to overcome this, various devices have been employed. Spence employed a skewer, transfixing the limb in front of the femur about the level of the great trochanter. Over the projecting ends of the skewer two pieces of elastic tubing are wound as a figure-of-eight, one across the front of the thigh and another across the back, thus constricting the vessels and preventing the tourniquet from slipping. With the same object in view, Trendelenburg employed a flat lance-point rod (15 by ¼ by 1/12 in.), and Wyeth employed two mattress pins (12 by 3/16 in.). Trendelenburg's pin is inserted 1½ inches below the anterosuperior spine, passed obliquely between the femoral vessels and the femur, touching the latter and emerging at the posterior scrotofemoral junction. The Esmarch tourniquet is wound in the figure-of-eight fashion so that it compresses all the soft structures in the front of the hip between the pin and the rubber tube. Wyeth's pins (Fig. 131) are passed through the root of the thigh: the first one is inserted slightly below and internal to the anterosuperior spine, passing superficially and engaging only the skin and fascia lata; the second pin is thrust through the abductor longus, enters ½ in. below the perineum, and emerges 1 in. below the tuberosity of the ischium. Above these pins the elastic tourniquet is wound. We consider these methods complicated and unnecessary.

5. Lynn-Thomas forceps-tourniquet (Fig. 39). See also page 282.

"A small stab puncture is made immediately below the anterosuperior spine of the ilium, and through this the internal probe-pointed blade is pushed forcibly toward the neck of the femur, parallel with Poupart's ligament, and driven home as far as it will go. The limb is then elevated vertically for a couple of minutes in order to exsanguinate it, then the forceps is clamped. This action effectually and simultaneously compresses the common femoral artery and vein. After the anterior flap is made and turned up, the gaping blood vessels are clamped by hemostatic forceps and afterward the forceps tourniquet is released and withdrawn and is then

passed behind the neck of the femur in order to control the blood vessels in the posterior flap. By this method the loss of blood during amputations of the hip joint has become practically negligible, and in quantity is not more than is always lost during amputation by any of the other so-called bloodless methods."

6. Manual compression of the abdominal aorta. Macewen controls the aorta by direct compression (Figs. 132, 133). An assistant stands upon a stool at the left side of the patient and forces his right fist into the abdomen, pressing the anterior wall against the aorta. He applies his fist immediately to the left of the umbilicus and swings the full weight of his body on it by crossing the right foot in front of the left. This position can be maintained for some time.

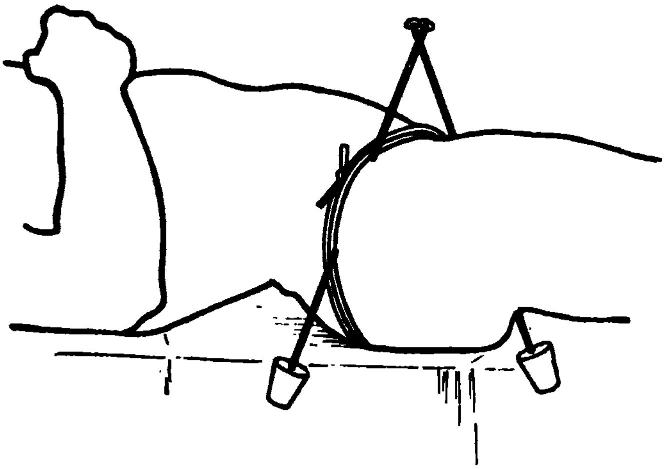


FIG. 131.—HIP-JOINT AMPUTATION. Wyeth's modification of the Trendelenburg's method. Pins and rubber tube in position. The Esmarch bandage has been removed.

The disadvantages of this method are that it requires a strong-handed trained assistant, and in stout and muscular subjects the compression may be uncertain.

7. Mechanical compression of the abdominal aorta. This can be accomplished by the use of the screw tourniquet, the fixed abdominal tourniquet and Momburg's constrictor. The latter method yields the most reliable hemostasis (Figs. 36, 37, 38). For its application, indication, contra-indication, and dangers, see page 281.

Methods of Disarticulation at the Hip.—Many methods have been proposed, Farabeuf mentioning 45. In former days speed was considered the essential feature of an operation, and many transfixion and flap transfixion methods were evolved. Safety having replaced speed, these methods have become obsolete. The two best methods are: (1) the amputation-resection and (2) extirpation. The former method is indicated in those cases where the soft parts can be retained, the latter where the soft parts must be sacrificed.

Amputation-resection Method (Ravaton-Brashear-Jordan) (Fig. 134).—In this amputation an external racket incision is used, the upper end of the shaft of the femur being shelled out and the muscles divided by a circular incision.

As in the shoulder, this method is the safest and best, provided the condition of the soft parts warrants its employment. It is conservative and practically bloodless, leaving a functionating muscular stump which is a material aid in fitting and using an artificial leg. As the transverse section of the limb is made at some distance from the trunk, the shock is considerably reduced. The scar being placed at a distance from the anal region, the dangers of infection are lessened. This method is contra-indicated in pathological conditions requiring the removal of the soft parts, i. e. sarcomata of the femur, etc.

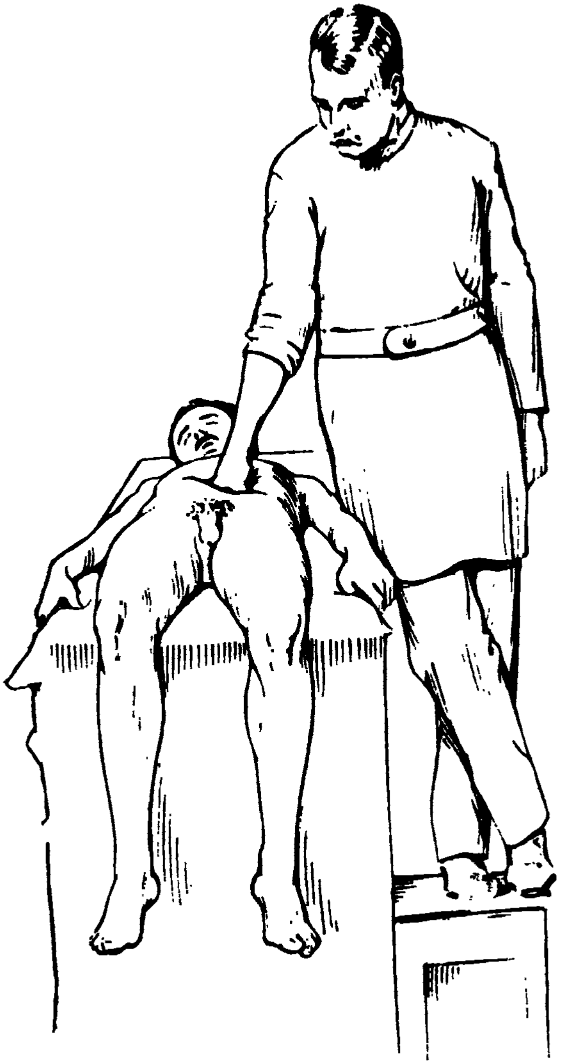


FIG. 132.—MANUAL COMPRESSION OF THE ABDOMINAL AORTA, FIRST STEP. (MACEWEN.)

TECHNIC.—Place the patient in a moderate Trendelenburg position, empty the limb of blood, and apply the elastic constrictor in the form of a figure-of-8 around the pelvis and thigh. With the buttocks resting on the end of the table and the limb held in a position of slight adduction, flexion and inward rotation, mark out the racket incision ABCDE. The handle of the racket AB begins 10 cm. (4 in.) above the great trochanter and extends downward 15 cm. (6 in.) on the external surface parallel to the posterior border of the vastus externus. The body of the racket BCDE is obliquely placed, the external point B being higher than the internal point D. The first incision includes the skin and deep fascia; these structures being raised by a few touches of the knife and

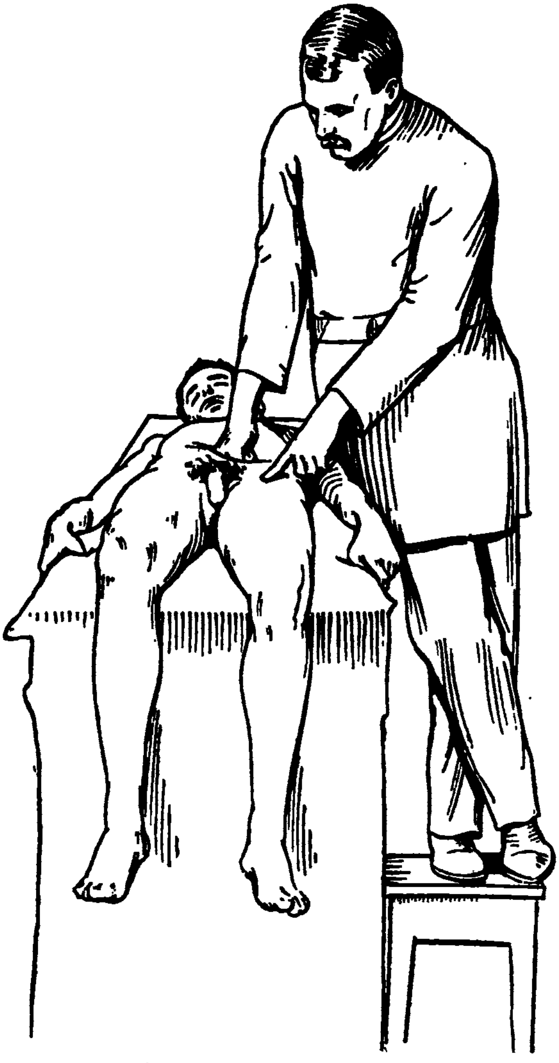


Fig. 133.—Manual Compression of the Abdominal Aorta, Second Step. (Macewen.)

etracted upward. A circular amputation is then performed at this level. The nterior crural and sciatic nerves are to be blocked with novocain before they re divided. Ligate the blood-vessels and treat the nerves before proceeding vith the remaining steps of the operation. Deepen the vertical incision AB, through the periosteum, to the bone. Strip up the soft parts subperiosteally, detaching the muscles from the trochanters. The detachment of the muscles from the linea aspera and trochanters is facilitated by the use of a chisel. Enter the joint from in front, divide the cotyloid ligament, force the head of the bone out by depressing the femur and rotating it outward. Divide the exposed ligamentous tissues, remove the head from the socket, and complete the disarticulation by dividing the posterior capsule. Attend to hemostasis. Make a 3-tier closure of the soft parts, muscle, fascia, and skin, and provide rubber tube drainage at the outer angle.

RESECTION-AMPUTATION METHOD (KOCHER, 1876).—Kocher has modified the amputation-resection method and reverses the steps to this operation. He disarticulates the head first and finishes by amputating the thigh. For the disarticulation of the head he uses his posterior curved incision over the trochanter, and goes through the fibers of the gluteus maximus. The amputation of the thigh is carried out by a circular or by an oval incision extending upward on the outer side.

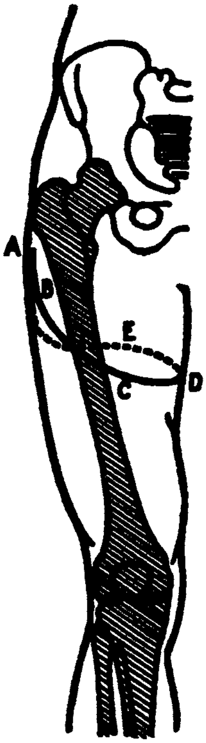


FIG. 134. — DISARTICULATION AT THE HIP BY AN EXTERNAL RACKET INCISION. (Raveton - Brashear-Jordan Op.)

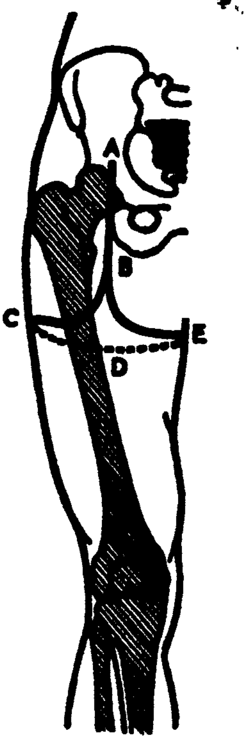


FIG. 135.—DISARTICULATION AT THE HIP BY AN ANTERIOR RACKET INCISION.

COMMENT.—In both of these operations, as no direct pressure comes on the stump, it is advisable to use the subperiosteal methods and maintain the insertion of as many muscles as possible. In this way a surprisingly useful stump is obtained.

Extirpation Method (Verneuil-Beck-Rose) (Figs. 135, 136).—According to Farabeuf, Verneuil proposed to extirpate the thigh like a tumor, dividing the larger vessels between two ligatures. The method was also practiced by Beck and improved by Rose. An anterior racket incision allows of an early ligation of the vessels, a direct exposure of the joint, and a more thorough extirpation in malignant diseases. It is also applicable in extensive damage to the soft parts. This operation, however, is accompanied by more shock than the preceding one.

TECHNIC.—Position and precautions against shock and hemorrhage also apply in this operation. Mark out the anterior racket incision ABCDE. The

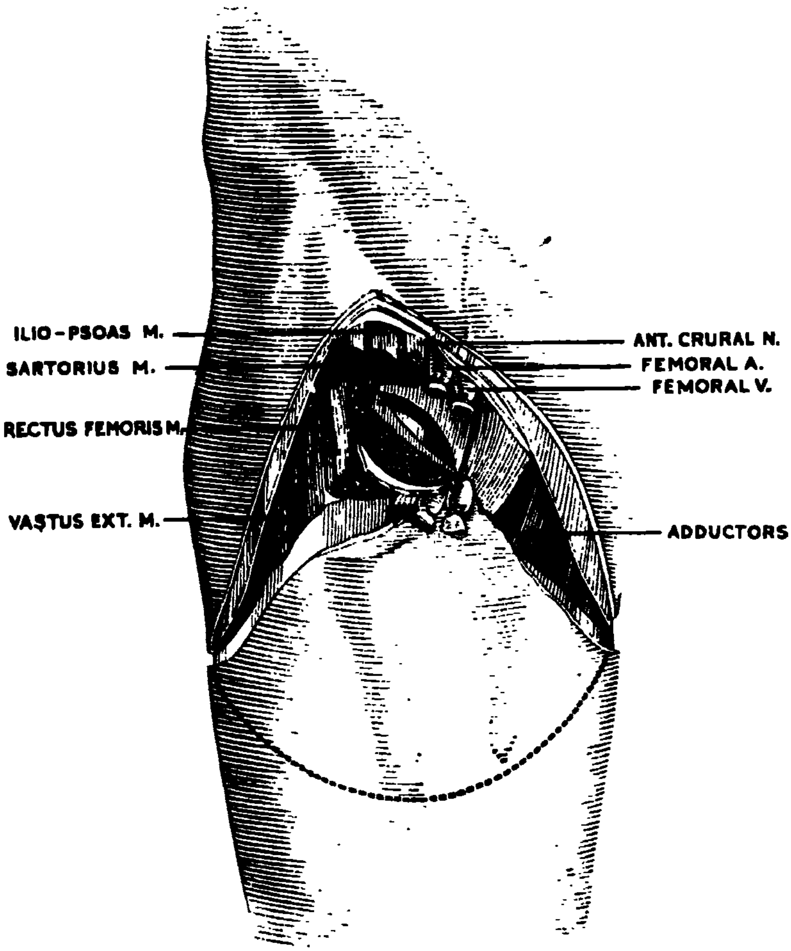


FIG. 130.—DISARTICULATION OF THE HIP. Extirpation method by the lanceolate incision. (Kocher.)

handle of the racket AB commences at the center of Poupart's ligament, directly over the line of the femoral vessels, and extends downward for 10 to 15 cm. (4 to 6 in.). The body of the oblique racket BCDE crosses the adductor muscles 10 to 12.5 cm. (4 to 5 in.) below the genitofemoral fold, traverses the posterior aspect of the thigh obliquely upward and outward over the outer side of the thigh at the level of the base of the trochanter to the point B. Carry the incision through the fascia and allow the wound edges to retract. Expose the femoral vessels and divide between double ligatures. Block the anterior crural nerve with novocain. Divide the sartorius, rectus, iliopsoas, tensor fascia femoris, and the remaining muscles on the anterior and exterior aspect of the thigh. Flex, rotate inward, and adduct. Divide the insertion of the gluteus maximus, increase the adduction, and divide the muscles attached to the great trochanter. Divide the muscles of the inner flap to the bone, adduct, and rotate outward; expose the lesser trochanter and detach the iliopsoas. Divide the cotyloid ligament and enter the joint from the front. Depress the limb and twist the head out. Block the sciatic nerve with novocain and complete the disarticulation by severing the remaining posterior structures. The cicatrix falls to the outer side away from the genital region.

After-treatment.—In all amputations of the hip large dressings are applied and fixed in position with adhesive straps and dextrin bandages. As soon as the wounds are healed, Hirsch's exercises are begun.

INTERILIO-ABDOMINAL AMPUTATION (JABOULAY)

History.—Billroth performed the operation in 1889, the patient died shortly after, and the case was not published (Klapp). Jaboulay performed and described this operation in 1894. Other pioneers in the work were Girard, Caccioppoli, Salistscheff, and Kocher, in Europe, and Keen and Freeman, in America.

Indications.—This operation has been performed for malignant growths of the pelvic bones, sarcomata of the femur with secondary deposits in the pelvis, and in a few instances for extensive tuberculous disease of the hip. It is very questionable whether such a formidable operation should ever be employed for the latter condition. If practicable, a partial resection of the pelvis, or amputation of the pelvis with retention of the posterior portion of the ilium (Freeman's operation) (Fig. 139), should be preferred to the formal interilio-abdominal amputation. By retaining the posterior ilium the operation is shortened and the difficulty of separating the sacro-iliac joint is avoided. Keen (Fig. 140) calls attention to the fact that by saving the descending ramus of the pubes, and the ascending ramus of the ischium, the bleeding that would come with the separation of the root of the penis is avoided. Axhausen suggests the closure of the pelvic rim by the osteoplastic procedure (Fig. 141).

Results of Operation.—The immediate and remote results of this operation are discouraging. Recurrences are very common, the primary mortality ranging from 70 to 75 per cent. The greatest dangers are from shock and hemorrhage. Ransohoff (1909) reports 34 cases of interilio-abdominal amputation with a mortality of 68 per cent.

While having no personal experience with the operation, work on the cadaver has led us to believe that the Kocher method is based on sound principles. Shock and hemorrhage can be reduced by employing Kocher's technic, Momburg's constrictor, and Lynn-Thomas' forceps-tourniquet. The following is Kocher's description:

Technic.—"The median basilic vein is exposed and everything is prepared for intravenous injection. The patient is placed on a well warmed operating table, and an enema of tea and brandy is administered. An incision is made parallel to Poupart's ligament exactly similar to that used in ligature of the common iliac artery (I in Fig. 137). (This might be effected under local anesthesia.) The fascia is divided in the form of an angular flap, the muscles are separated in the direction of their fibers, the fascia of the transversalis is raised along with the peritoneum, and the internal iliac fossa and the common iliac artery are exposed. The artery is temporarily controlled with a suitable compressor or clamp (Halsted), and after the vein has been emptied by elevating the limb, it is also clamped. We regard temporary closure of the vessels as a necessary precaution against collapse from acute anemia. The inner surface of the pelvis is now carefully investigated, the limits of the tumor are defined, and the proposed lines of section of the pelvis are determined.

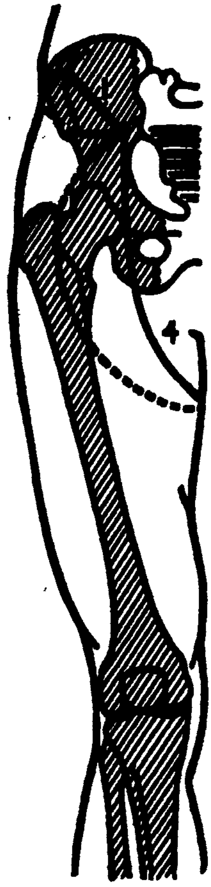


Fig. 137.—Interilio-abdominal Disarticulation. Anterior view. (Kocher.)

"The dorsal aspect of the innominate bone is then similarly examined. This is most satisfactorily effected through an incision in the same direction as that for ligature of the gluteal artery (2 in Fig. 138), only considerably longer and more like the one we recommend for posterior excision of the hip at the upper border of the gluteus maximus. The great sacrosciatic notch is thus exposed, and the line at which the bone is to be divided is defined. After its fibers have been split, the gluteus maximus can be drawn downward with a hook without any appreciable bleeding; and the bone is exposed at the upper border of the great sacrosciatic notch, where it is to be divided, or, alternatively, the lower end of the sacroiliac synchondrosis is exposed. The tendon of the pyriformis is next cut across and the trunks of the great and small sciatic nerves are exposed and divided in the lower part of the great sacrosciatic notch. The shock incurred by division of the great sciatic nerve may be avoided by an injection of novocain. With a hammer and chisel, the base of the ischial spine is then cut through to the outer side of the internal pudic artery and nerve, and the inner aspect of the gemelli and the obturator internus followed downward to the sacrosciatic ligament, the descending ramus of the ischium being then chiseled through into the foramen ovale above the attachment of the ligament to the ischium and the tuberosity; in this way the tuber ischii is only held by the ligament and the muscles of the perineum. The anterior and posterior incisions are now

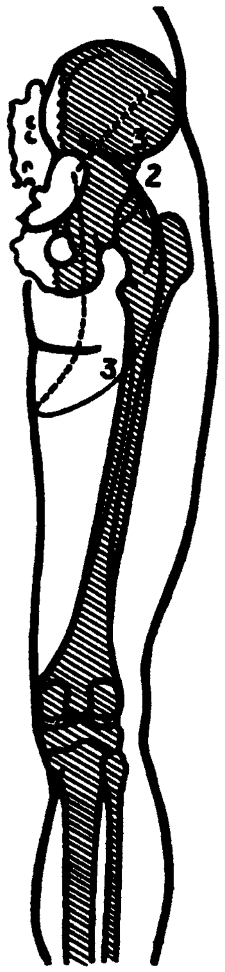


Fig. 138.—Interilio-abdominal Disarticulation. Posterior view. (Kocher.)

joined, as shown in Fig. 138, No. 3. Crushing forceps are pushed underneath the gluteus medius and minimus in the proposed line of section of the ilium, and the muscles are then divided between two clamps, the application of the clamp being preferable to division of the muscles at their attachment to the bone. A finger is now inserted into the anterior incision (Fig. 137, No. 1), two pairs of clamp forceps being introduced along it, and the abdominal muscles are clamped just above the crest of the ilium. They are then divided between the forceps as far as the line of section of the crest posteriorly. The iliopsoas is next dealt with. The external iliac vessels, together with the ilio-inguinal and genitocrural nerves, are raised and retracted; but the nerves which descend at the side of the psoas and iliacus, namely, the anterior crural and the external cutaneus, are divided. The iliopsoas is cut across between two forceps and the bone is divided with a chisel, bone forceps, or Gigli saw, from the sacrosciatic notch upward along the selected line. The anterior portion of the flap incision (Fig. 137, No. 4) is now carried vertically downward on the anterior surface of the adductors, thus exposing the horizontal and descending ramus of the pubis, with the femoral vessels lying externally. The latter are ligated above the origin of the profunda so that the internal circumflex vessels may be retained in the flap. The pubis is next divided with a chisel or bone forceps as shown in Fig. 139 or Fig. 140 (Keen), separating the attachment of the internal and external obturator muscles from the foramen ovale. The obturator externus is then cut across. The innominate bone can now be drawn downward and outward, being only held by the levator ani. The pelvic fascia and periosteum are divided at the entrance to the true pelvis as far as the horizontal ramus of the pubis, preserving the obturator vessels and nerve and strip of fascia by which the levator ani and coccygeus are attached. Finally, the skin incisions are completed, the adductors and the hamstrings are

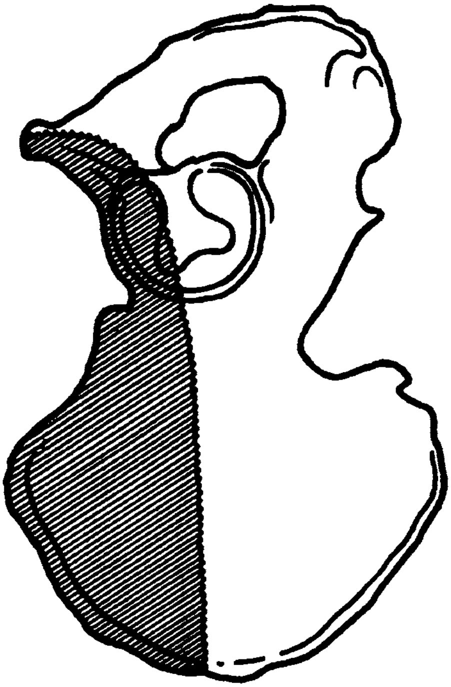


FIG. 139.—LINE OF SECTION IN FREEMAN'S CASE OF AMPUTATION OF THE PELVIS.

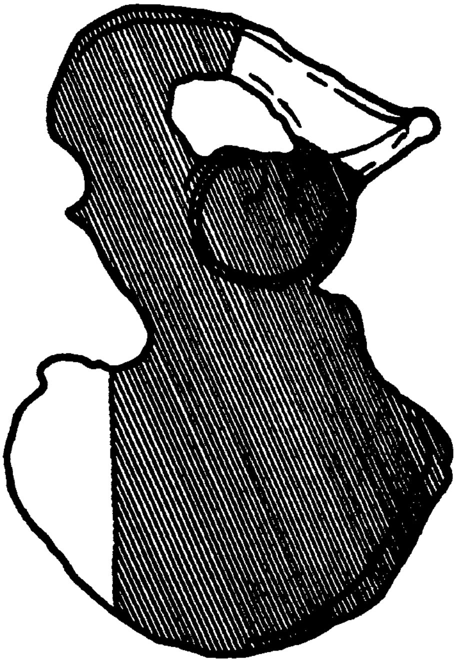


FIG. 140.—LINE OF SECTION IN KEEN'S CASE OF AMPUTATION OF THE PELVIS.

divided at their origin from the tuber ischii, and the vessels are tied seriatim. The forceps, which still grasp the muscles, are now removed one at a time, and the vessels are tied.

"After transfusion, the temporary clamp on the common iliac artery is removed and any branches of the obturator, circumflex, gluteal and sciatic arteries which may still be bleeding, are immediately secured. Our incision corresponds in the main with that of Savariaud and Keen."

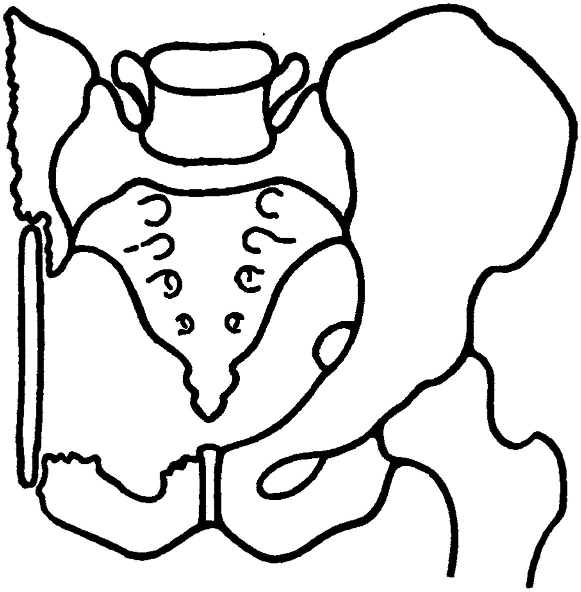


Fig. 141.—Bone Plastic to Close the Pelvic Rim in Interilio-abdominal Disarticulation. (Axhausen.)

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DISEASES OF THE JOINTS AND BONES

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CHAPTER VII

DISEASES OF THE JOINTS AND BONES

Clarence A. McWilliams

DISEASES OF THE JOINTS

ACUTE NON-INFECTIOUS SYNOVITIS

Acute synovitis of non-infectious origin, such as that caused by trauma, should be treated by absolute rest. The limb should be placed on a splint in the position which will be most useful should adhesions form. Pressure, at first slight and never sufficient to cause pain, should be applied by means of smooth turns of a rubber bandage, being gradually increased day by day. The object of this pressure is to limit the amount of effusion and to conduce to its more rapid absorption. An ice bag should, intermittently, an hour at a time, be placed over the rubber bandage. As soon as the fluid is gone, massage and passive motions are in order. The fluid may persist and go on to the chronic form.

ACUTE INFECTIOUS ARTHRITIS

To treat this properly and efficaciously often requires great insight and skill. The chief infecting agents are the ordinary pus cocci, the gonococcus, the typhoid bacillus, the pneumococcus, and the meningococcus.

The success of treatment most often depends upon the recognition of the underlying cause, and it should not be forgotten that most frequently arthritis, both acute and chronic, is only a symptom of a disease whose real nidus is in some distant part of the body. A urethritis, or other genito-urinary infection, suppurating antral, ethmoidal, frontal, or mastoid cells, gastro-intestinal sepsis, diseased tonsils and adenoids should not be overlooked in eliciting the etiology, and these will require appropriate treatment before the arthritis can be cured. Frequent causes of arthritis are carious stumps of teeth, decay beneath an apparently good filling, and very frequently pyorrhea alveolaris. In obscure cases it will be best to get a röntgenogram of the teeth, which may make evident a pus cavity, or cavities, at the roots of the teeth, with or without necrosis of the alveolar process. Swelling of joints with high temperature may be due to a condition of anaphylaxis caused by an injection of serum. A similar condition may occur in dysentery, and it is common in pyemia and septicemia. It at times, as mentioned, follows the acute infectious diseases, such as scarlatina, measles, and small-pox. It follows punctured wounds, compound dislocations, and fractures (see Wounds of Joints).

If it be possible to obtain an organism from the original focus of infection, a vaccine should be made from this and administered to the patient at appropriate intervals and dosage. Aspiration of the affected joint is a most valuable help in the diagnosis when the surgeon is in doubt. Pus cocci and pneumococci may often be demonstrated, more rarely gonococci, typhoid bacilli, and meningococci.

Typhoid Arthritis

The hip is the joint most frequently affected. Rest and protection by splints should be used. To prevent the frequent dislocation, the attitude of flexion and adduction should be avoided by applying extension to the lower extremity. Aspiration of the fluid should be employed and the subsequent injection of half an ounce of a 2 per cent. formalin in glycerin solution is advised. If a pus infection be added, the ordinary treatment of a suppurating joint must be employed.

Gonorrheal Arthritis

This is commonest in the knee, but the tarsal and carpal joints, ankle, and hip are also frequently affected, and any joint in the body may be attacked, or it may occur in several joints simultaneously. The urethritis has usually passed into the chronic stage and through the urethroscope one sees congested patches in the urethra.

The treatment consists, first, in local applications to the patches in the urethra. Internal remedies such as oil of sandal-wood and copaiba give little benefit. [In these cases I have found sandal-wood oil of great benefit. ℞. Santal Midi, M. 10 every 4 hours.—Editor.] Autogenous vaccines and antigonococcus serum should also be employed. The diet should be light and no stimulants allowed. Absolute rest should be ordered and the patient put to bed. The joint should be enveloped in cotton-wool, which is firmly bandaged so as to exert as much even pressure as can be borne without pain, and a light plaster splint applied to immobilize the joint. An ice bag will relieve the pain and tenderness. Counter-irritation is often of value, and in mild cases tincture of iodin may be painted over the joint until the skin becomes sore. In severe cases blisters may be applied. When the pain disappears an elastic bandage may be applied over the cotton-wool and the pressure gradually increased. If recovery is slow, Bier's hyperemic treatment may be used to advantage. As soon as the pain and tenderness have disappeared, massage, hot-air baths, applications of superheated air, and active and passive motions should be employed. At the beginning massage should be given once a day for about a quarter of an hour. After a few days it may be practiced twice a day, the pressure being maintained between the periods of massage. Extensive effusions should be removed by repeated aspirations, since otherwise the ligaments may be stretched and a loose joint result. The joint may be washed out, following aspirations, by either a 3 per cent. solution of carbolic acid or a 1 per cent. watery sublimate solution, or a 2 per cent. formalin in glycerin solution. Should suppuration occur, drainage of the joint should be made. In persistent cases drainage of the seminal vesicles (see Chronic Gonorrheal Arthritis) may be invaluable.

LEUKORRHEAL ARTHRITIS

This may occur in women suffering from leukorrhea, and is undistinguishable clinically from arthritis due to gonorrhea. The cause should be ascertained and the local condition carefully treated, upon which the joint symptoms will rapidly subside. Local treatment as for gonorrheal arthritis should be adopted.

PNEUMOCOCCAL ARTHRITIS

The true nature of the infecting organism is easily ascertained in smears of the pus, or from a culture of the joint fluid. Vaccines from these should be given. In mild cases immobilization of the joint with aspiration and washing out, may suffice, and numerous cases recover with complete restoration of function. If the joint be full of pus and the constitutional symptoms severe, the sooner the joint is drained the better for the subsequent restoration of function. Bulkley (3) analyzes 172 cases, among which the mortality was 50 per cent.

PUNCTURE, ASPIRATION, AND INJECTION OF INDIVIDUAL JOINTS

The preparation of the patient, surgeon, assistants, and apparatus must be as careful as for an arthrotomy.

Hip Joint.—A trocar and cannula are employed, 2¾ to 3½ inches in length. The thigh should be in adduction and slight internal rotation. The trocar is introduced immediately above the tip of the trochanter major, midway between its anterior and posterior borders, and is held at right angles to the axis of the femur. At the point of injection insert a hypodermic needle and inject under the skin a few drops of a 4 per cent. novocain solution. The trocar is inserted until its point strikes the head of the femur, or the neck near the head. The limb is then strongly adducted, when the instrument is pushed upward and inward until the point comes to lie between the head of the femur and the rim of the acetabulum. The cannula is withdrawn and the instrument still further inserted into the joint, all the fluid is allowed to escape, and, if no washing out or injection of the joint is to be practiced, the instrument is withdrawn, a sterile dressing applied, and a bandage put on which will exert pressure on the joint. The joint may be washed out with sterile salt solution. This is done with an irrigator or a common sterile glass syringe attached to the cannula by sterile rubber tubing. Many follow the lavage in cases of more mild sepsis by injecting a 5 per cent. solution of carbolic acid, or a 2 per cent. solution of formalin in glycerin (24 hours old), or of a 1 to 4,000 sublimate solution. When tuberculosis is present one may inject a sterile emulsion of iodoform in glycerin (iodoform 10 per cent., formalin 2 per cent., glycerin q. s., Murphy).

FROM RUNGNER'S POINT.—The aspiration may be made from in front at the median edge of the sartorius on a line which joins the place where one can compress the femoral artery against the pubic bone and the tip of the trochanter major. One lays the index finger of the left hand upon the vessels to avoid injuring them, and directs the trocar antero-posteriorly into the depths, where, with great certainty, particularly in joint effusions, he comes upon the capsule at the upper edge of the femoral neck.

Knee.—At a point just above and external to the patella inject a few drops of a 4 per cent. novocain solution. Puncture the skin in this area with a knife, and through this puncture pass a trocar and cannula down and in until the point is made to touch the articular surface of the patella. This indicates that the needle has entered the joint. Withdraw the cannula and allow the fluid to escape. Washing of the joint and injection may follow (see under Hip).

Ankle.—The bulging caused by fluid effused into this joint is first noticed in front of the malleoli on either side of the extensor tendons. As the position of the joint does not affect its capacity and the flexor and extensor muscles about equal each other in power, the foot does not assume any characteristic position when the ankle is inflamed. The bulging in front of the external malleolus is the best point to puncture, aspirate, wash out, or inject the joint. (For solutions, see under Hip.)

Elbow.—Puncture of the elbow is made as follows: Palpate the position of the head of the radius and just above the radial head, on the outer side of the arm, introduce a trocar and cannula at right angles to the long axis of the extremity.

Wrist.—This joint may be punctured on the posterior aspect, either to the outer or inner aspect of the extensor tendons, where the effusion causes bulging of the capsule.

Acute Suppurative Arthritis

Suppuration in a joint caused by ordinary pus cocci is one of the severest accidents which can happen to a patient, and the surgeon should take all precautions in operating in the vicinity of joints that no infection is introduced into the joint cavity, and all joint operations themselves should be carried out with even more vigorous asepsis, if possible, than usual, since joints resist infection very poorly. Tuberculous joints should never be opened for drainage only, unless they be secondarily acutely infected with ordinary pus cocci. Conservative treatment is permissible in cases where aspiration reveals the presence of a few pus corpuscles in a joint and the constitutional symptoms are not severe, particularly if the aspirated fluid does not show streptococci. Vaccines should be made at once from the organism obtained in the aspirated fluid and administered. The joint should be immobilized with an appropriate splint, and should be aspirated every two or three days; this should be followed by washing the joint out with sterile salt solution, followed by the injection of half an ounce to an ounce of a 2 per cent. formalin and glycerin solution. If the infection is in a joint in the lower extremity, the comfort of the patient will be increased by a Buck's extension. Daily bakings or the application of superheated air, combined with Bier's hyperemia, will help to allay the inflammation. An ice bag or hot fomentations may also be used. If the symptoms grow worse, or if from the start they are severe, and, if aspiration reveal streptococci or even staphylococci, then no time should be lost in opening and draining the joint by free incisions and inserting through-and-through drainage tubes. Following these incisions the best methods of treatment are continuous irrigation or the continuous water bath, preferably the former.

Continuous Irrigation. In carrying this out the limb should be placed upon some sort of splint. One of the most useful is that composed of wire netting or perforated zinc, cut to shape and moulded so as to fit the limb accurately. The skin around the wound should be smeared with sterile vaselin and mackintoshes should be arranged around the extremity, so that the fluid is conducted into some suitable receptacle. The nozzle of the irrigator should then be connected with the highest drainage tube. The fluid should be salt solution or tincture of iodin (a dram to the pint) at the body temperature, allowed to trickle slowly through the tube. The nozzle should be attached to the various drainage tubes in succession so as to flush out the whole joint.

The Continuous Water-bath. When irrigation cannot be practiced, the limb should be immersed in a water-bath night and day, all dressings being removed. The fluid should be changed frequently.

Drainage of Joints.—DRAINAGE OF THE HIP. Suppuration in the hip joint is most frequently due to acute epiphysitis of the upper end of the femur. An anterior and a posterior incision should be made to provide for drainage. The anterior incision is made first and begins 1 inch below and ½ inch internal to the anterior superior spine, and is carried downward and inward for 3 or 4 inches. It is deepened until the inner border of the sartorius is exposed, which is retracted *outward*. The tendon of the rectus femoris then comes into view and is likewise retracted *outward*. Beneath is the psoas iliacus muscle, which is retracted *inward*. This exposes the joint capsule, which is split transversely over the head and neck. In every case counter-openings for better drainage should be made through the posterior part of the joint. A long, stout pair of dressing forceps should be pushed from the anterior opening in the capsule through the posterior part of the capsule, and made to project in the buttock, as close as possible to the trochanter. The ends of the forceps are cut down upon behind and are pushed through the opening. They are then expanded so as to enlarge the opening, and they next grasp the end of a drainage tube, with holes for drainage cut in the side, which is pulled through the joint. First, however, careful inspection of the head and neck should be made to determine whether the suppuration be due to acute epiphysitis. If this be found to be the cause, the best plan is to remove the head and neck of the femur. Immediately upon removing the head, the cut end of the neck should be swabbed with undiluted carbolic acid, which forms an albuminate, which seals up the cut surface and helps to form a barrier to prevent osteomyelitis. In some cases necrosis of the cut surface will take place, and in three or four months after separation has occurred it will be necessary to remove the necrosed fragment or fragments. A second drainage tube should be inserted into the joint in front, and the joint thoroughly washed out. Sterile dressings should be applied and the hip put up in abduction with a Buck's extension on the extremity to prevent the flexed position being assumed. To prevent rotation a transverse splint should be fastened behind the knee joint with plaster-of-Paris.

THE ACETABULUM may become affected with osteomyelitis. This will require removal of the head to effect proper access, after which the walls of the acetabulum should be gouged out to remove diseased bone. The whole thickness of the bottom of the acetabulum should be removed so that no puddle of pus can remain undrained in this locality. Frequent examination by rectum should be made to determine any pelvic collection of pus. Such a collection should be drained through an incision made at the inner side of the tuberosity of the ischium. If pus be found in the iliac fossa, an incision should be made just internal to the anterior superior spine, care being taken to push up the peritoneum so as to avoid opening the peritoneal cavity.

The joint will most certainly become ankylosed, hence it should be kept in the abducted position. Later will come the decision as to the advisability of a Murphy's arthroplasty to obtain motion.

DRAINAGE OF THE KNEE.—A. ANTEROLATERAL INCISIONS.—For exploration or to remove serum or blood from the joint one incision in front will suffice. The incision is vertical, one finger's breadth external to the patella. It may be small in some instances, but if pus be present, longer incisions will be necessary, extending upward above the patella 1½ in. or more, so as to drain the pouch above, and downward to the upper border of the tibia. A second incision on the outer side should be made likewise. If drainage is required, insert a tube just inside the synovial membrane on either side just above the patella. It may be necessary also to provide posterior drainage on one or both sides. In this case counter openings may be made at the original operation or later on as occasion may require. They are made as follows: Pass a short dressing forceps through the external anterior incision and with it raise up the soft parts on the outer side, just anterior to the hamstrings, thus avoiding the external popliteal nerve; on the inner side it may go between the tendons. Cut down with a knife upon the forceps, which are pushed through and opened. The forceps then seize a drainage tube and draw it into the joint.

A more rational method of draining the joint is to make posterior incisions at the primary operation, thus giving the best method of draining the joint.

B. Posterior Drainage.—*On the Outer Side.*—Slightly flex the knee and locate the biceps tendon, make an incision through the skin and fascia 2½ in. long in front of and parallel to the tendon. Retract the biceps tendon backward and expose the posterior border of the external condyle of the femur. Open the capsule and enlarge the opening, as may be desired.

On the Inner Side.—Extend the knee and flex the thigh on the pelvis. This allows one to see and palpate a longitudinal groove beside and behind the internal condyle. The inner border of the groove is formed by the gracilis and the outer border by the semitendinosus. Make a longitudinal incision through the skin and fascia in the above groove, with the middle of the incision opposite the line of the knee joint. Expose the sartorius and, half hidden by it, the gracilis. To the outer side of these tendons note the narrow tendon of the semitendinosus and, more deeply situated, the large semi-membranosus tendon. Retract these tendons backward and open the joint on the posterior border of the internal condyle of the femur by an incision reaching from the border of the meniscus to the upper end of the capsule. The serous bursa under the semimembranosus is felt by the finger and opened. To avoid drainage tubes it has been suggested that the synovial membrane be stitched to the skin by catgut sutures. It would seem wise, however, in severe infections to insert a drainage tube just inside the synovia to keep the edges of the incision open.

Curved Incision with Reflexion of Patella Upward (Peck's Operation).—The infection may not be overcome even with four incisions as above, and some further attempt to provide adequate drainage will be necessary, in which the curved incision with reflexion of the patella upward may be employed (Fig. 1). The incision is carried downward, divides the ligamentum patellæ, and extends from the posterior border of one condyle to a corresponding point on the other condyle. Divide the anterior capsule, both lateral and both crucial ligaments, C, allowing the posterior ligaments, D, alone to remain intact. On each side make a lateral cut upward sufficient to permit the complete turning upward of the anterior flap, including the patella, B, and all the tissues down to the joint. This exposes all parts of the upper synovial pouch. Keep the patellar flap in its new turned-up position by a stitch, A, between it and the skin of the thigh. Keep the knee flexed to such an extent that the whole popliteal surface of the joint is exposed but no injurious compression is exerted on the popliteal vessels. Wash the joint with salt solution and pack every crevice *loosely* with gauze wet in salt solution. Mould a posterior splint out of plaster-of-Paris bandages in the extreme flexed position. Watch the circulation of the foot lest it be impeded by too great flexion. Subsequently allow salt solution to trickle drop by drop continuously on the dressing. Dress daily under nitrous oxid anesthesia. In many instances even this radical procedure will be insufficient and amputation will be necessary to save life.

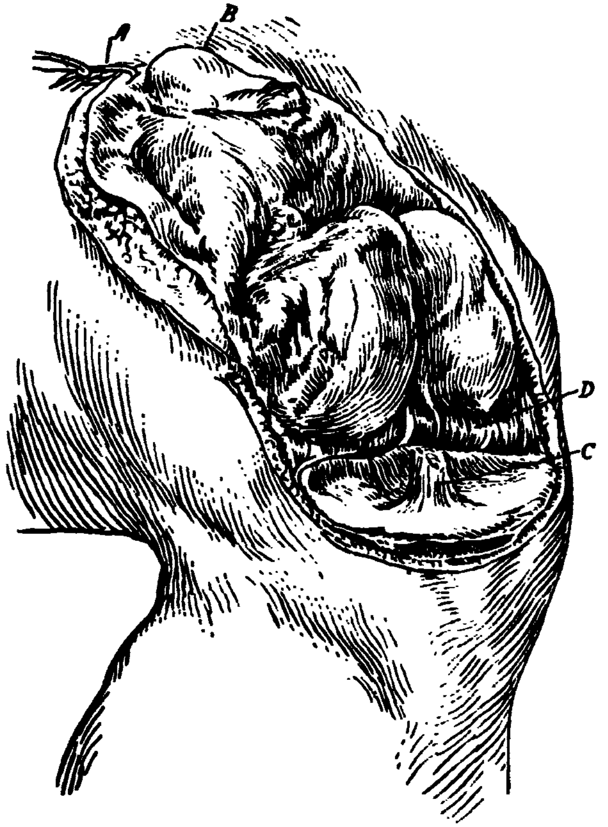


Fig. 1.—Drainage of Knee. A, Stitch between flap and skin of thigh; B, patella; C, divided crucial ligaments; D, posterior ligaments. (Peck.)

If the infectious process abate, Peck and others recommend performing arthrectomy at once, since it more than likely will be impossible to close the wound, on account of the shrinking of the skin flap, without removing the articular surfaces, and a fibrous ankylosis is certain to result with possibly a subluxation of the tibia on the femur. Every patient, however, should be judged by the conditions present. In cases in which the infection rapidly subsides (rare) the flexion should be gradually straightened out. When full extension is obtained, the flap should, if possible, be sewn in position, particularly the ligamentum patellæ, providing for lateral drainage. Early motion should be made. Ankylosis is almost the rule. When the joint is healed, arthroplasty may be tried or, if the joint be painful on walking, a resection may be done.

Drainage of the Ankle.—Make a 2-inch vertical incision along the anterior border of the external malleolus, ending ½ in. below the tip of the malleolus. On the inner side of the incision are the extensor tendons and the peroneus tertius. Divide the annular ligament and open the joint immediately in front of the malleolus. Pass a closed forceps across and through the joint to the inner side, keeping it in contact with the bone throughout and lying behind the synovial sheath of the extensor tendons. The soft parts are raised by the forceps in front of the internal malleolus, the points are cut down upon, and a fenestrated rubber tube is drawn through. If the double anterior arthrotomy wound is insufficient for drainage, a posterior counter-puncture should be made to the outer side of the tendo Achillis. If an incision is added on the inner side, cut close to the inner border of the Achilles tendon, retract the posterior tibial vessels and nerve, and the flexor tendons of the foot inward, and incise the joint between these structures and the tendo Achillis.

ASTRAGALECTOMY FOR DRAINAGE. Removal of the astragalus is practically the only thorough method for draining cases of severe infection of the ankle. See under Excision or Resection of the Ankle, page 109.

STERNOCLAVICULAR AND TEMPOROMAXILLARY ARTICULATIONS. Suppurative arthritis of the sternoclavicular and the temporomaxillary articulations will at first require simple drainage. Since, if this is not sufficient and the infection progresses, we cannot amputate, the only alternative is excision of the articulation. (See under Resections of Joints.) In doing this care should be exercised not to infect the medulla of the bone. The pus is washed out of the joint, and sufficient bone removed to lay the joint cavity freely open. The raw surfaces are thoroughly covered with undiluted carbolic acid, which forms an albuminate over the surfaces, thus preventing absorption of infection into the bone. This is washed away with alcohol. The cavities are then packed loosely with wet gauze. As a rule, the cases thus treated do well.

SHOULDER ARTHROTOMY FOR DRAINAGE. Of all the large joints of the extremities, the shoulder joint is the least disposed to inflammation (1.6 per cent. in 896 cases, Hueter). It is not even frequently affected in polyarthritis. If in a suppurative infection a single incision is thought adequate, the best one for drainage is made behind. It begins at the angle of the acromion process and runs downward along the posterior border of the deltoid for 2 or 3 in., opening the subdeltoid bursa. By retracting the edges of the wound the joint capsule is exposed, which is crossed by the infraspinatus and teres minor tendons. The capsule should then be incised and the joint exposed so as to determine whether a resection is demanded. Drainage should be carried out with tubes. To this incision may be added another at the apex of the axilla, thus draining the lower part of the joint.

In severer infections anterior, posterior, and possibly inferior incisions may be demanded. The anterior is made first. The incision is vertical through the deltoid or oblique in the direction of the deltoid fibers, which are separated. The joint capsule is incised and the biceps sheath opened. The tendon of the biceps is drawn outward, and a dressing forceps is passed from in front posteriorly through the joint, between the glenoid cavity and humeral head. This is then cut down upon from behind at the posterior border of the deltoid. A rubber drain is then drawn into the middle of the joint from behind, and one from in front is inserted a short distance into the joint. The wounds are left open and loosely packed with gauze. A large gauze dressing is applied about the shoulder and thorax and firmly held in place by a bandage, and the forearm is placed in a sling. After cessation of the suppuration and fever, the anterior tube is first withdrawn and then the posterior. One begins as early as possible with active and passive motions, particularly rotation and upward elevation from the side. To the anterior and posterior drains may be added one in the axilla, made by directing the dressing forceps, passed from the anterior incision, downward, where it is cut upon at the apex of the axilla.

DRAINAGE OF THE ELBOW.—Incisions should be made on each side of the olecranon so as to drain the olecranon fossa, and possibly others in front of each condyle so as to drain the front of the joint. In each incision rubber drainage tubes should be inserted into the joint and continuous irrigation established, or the elbow inserted in a continuous water-bath without any dressing being applied about the joint.

DRAINAGE OF THE WRIST.—In the wrist proper drainage is very difficult to obtain, and can only be accomplished by laying the joint freely open in several places, particularly on the posterior and inner aspects. (For incisions, see Resection of Wrist.)

ACUTE INFLAMMATIONS OF THE SPINE

The vertebral joints are but rarely involved in an acute suppuration or in an acute gonorrheal or pneumococcal inflammation. Typhoid infection of the synovial membrane of the intervertebral joints is much more frequent. Suppuration in a typhoid spine is unknown, but the possibility of a tuberculous lesion following typhoid fever must be remembered. The patient always recovers, usually completely, but the recovery is slow and tedious, a year being the average duration of the severe cases. The treatment of typhoid spine is rest, the milder cases being strapped to take the strain off the spinal joints. Severer cases demand a light spinal brace or a plaster jacket. For the severest cases recumbency is necessary, preferably on a gas-pipe frame.

CHRONIC ARTHRITIS

Chronic arthritis is the expression in the joint tissues of a long-continued irritation. Most, if not all, the cases of chronic joint diseases are divisible into two main classes, or types. (The classification given by Dr. Leonard W. Ely will be followed.)

Type I.—Type I includes cases characterized by proliferation of the synovia and marrow, followed by atrophy of bone and cartilage. Under this heading fall tuberculosis, chronic gonorrheal and syphilitic arthritis, rheumatoid arthritis (or atrophic arthritis), and arthritis deformans. The view is gaining ground that all of this group are probably of infectious origin. In this class also come non-traumatic simple synovitis and intermittent hydrops.

Type II.—Cases characterized by inflammation and degeneration of the synovia, by degeneration of the marrow and by resulting hypertrophy of bone and cartilage, constitute this class. Under this head are grouped cases of ostearthritis, Heberden's nodes, etc.

Simple Synovitis.—Tuberculosis, gonorrhea, and syphilis should be fairly easily recognized, as well as traumatic synovitis.

Any organism which can cause an acute arthritis can cause a chronic one, hence the importance of ascertaining a focus for possible absorption, either of organisms or their toxins. Gastro-intestinal disturbance, visceroptosis, gonorrhea, pregnancy, labor and the menopause, diseased tonsils, suppurating teeth, infected sinuses of the nose, a history of an old, perhaps forgotten, chancre, all these and other sources of infection should be looked into. The frequent occurrence of pyorrhea alveolaris in pregnancy should be noted. Appendix and gall-bladder diseases should be sought for. Vaccines should be made at once from any focus and administered.

TREATMENT.—One or more joints may be involved at the same time or in succession, and fluid may be present or absent. If symptoms persist, the joint may be strapped with adhesive tape or placed on a posterior splint until the fluid is gone. The joint may be baked or massaged. Hydrotherapy or vibratory massage will often be found useful. Counterirritants, such as applications of tincture of iodin or blisters, may be used. Those cases dependent upon absorption of intestinal poisons will be benefited by purging, hence the benefit of many spas. If gross prolapse of the abdominal organs be present, they should be held in place either by an operation, or, more frequently, by the use of apparatus and exercises to support the abdominal wall. The usual form of apparatus is a light spinal brace, with an apron over the lower abdomen. Goldthwaite puts his severe cases to bed for a while on a hard mattress, with their shoulders low and a firm cushion in the back of their middle thoracic spine, with the idea of expanding the chest, pulling up the diaphragm, and thus making room for the displaced abdominal organs. His results seem excellent.

Severe or Multiarticular Group. This group is essentially multiarticular and progressive, involving various joints in succession. A focus of infection is thought to exist somewhere in the body in every case (see preceding section). An increased excretion of calcium salts has been detected in these cases, which is what one would expect when the bone is atrophying. Fibrous adhesions may form between the degenerated cartilage and its fellow of the other bone entering into the articulation, or between it and the synovia, or between both. Bony ankylosis may also occur as well as subluxations and distortions. The disease usually attacks first the joints of the fingers and travels toward the trunk.

Still has described a special form of this disease, occurring in children before the second dentition, and accompanied by enlargement of the lymph nodes and of the spleen. The swollen lymph nodes are very suggestive of an infection.

TREATMENT.—As in the preceding class, so in this, the treatment to be successful must find the focus from which absorption is taking place and eliminate it. For the possible foci, see the preceding class. Remarkable results have followed splitting and draining the seminal vesicles in cases resisting all other forms of treatment (see under Chronic Gonorrheal Arthritis). It must be remembered that it is the secondary infection following upon a gonorrheal infection of the seminal vesicles which causes the joint lesions, and this cause may act for years.

If after careful study we are unable to find the cause, we must fall back upon empiricism (Ely). Our first thought is of syphilis without other manifestations. Antisyphilitic treatment should be carried out for six months, relying upon mercury and salvarsan. Failing in this treatment, we may empirically administer powdered extract of thymus gland (grains 10, 3 times a day), or extract of thyroid or suprarenal gland, or milk which has undergone lactic acid fermentation.

LOCAL TREATMENT.—During the acute stage, or exacerbations, rest in bed should be enjoined, with a splint upon the joint, the knees being kept in complete extension and the elbows and ankles at a right-angled flexion. Applications of heat or cold may allay the pain, as also may the salicylates, which are palliative but not curative. During the remissions the patients should be encouraged to get about in the open air, the affected joints being supported by some form of movable brace, which not only protects them from injury, but also permits motion through a limited arc. Passive motion to the limit of toleration will preserve all the motion that is possible. Massage and Zander exercises should be used, as well as the Bier treatment by passive congestion.

Operative treatment will be rarely indicated except occasionally in those joints, such as the knee, where the disease has run its course, and has left behind it hypertrophied fringes which mechanically interfere with function. In these cases one may open the joint and trim away the fringes.

TUBERCULOUS ARTHRITIS

Ely says: "Tuberculosis manifests throughout the body a marked affinity for epithelial, endothelial, and lymphoid tissues, and, if unmixed with a secondary infection, it rarely attacks directly any other tissues whatever, but simply affects them by interfering with their nutrition." He goes on to remark: "In the region of the joints we find two lymphoid structures, the red marrow and the synovia. The unmixed disease never occurs in the shafts of the long bones, where ordinary yellow or fatty marrow is formed. In children the original focus is said to be almost invariably in the marrow; in adults, though good authorities differ on this point, the synovial form is probably of about equal frequency with that of the marrow. The disease must find its pabulum in the two lymphoid tissues (marrow and synovia), and, if we can cause the disappearance of these two tissues, the disease cannot exist."

The usual result of joint tuberculosis is a more or less damaged joint with a restriction or abolition of motion. The ankylosis is always fibrous. Bony union never takes place except after resection, or in children after a mixed infection. No exostoses ever form in tuberculous joints. Joint fungus is a name given to those cases in which an extreme proliferation exists in the synovia, while caries sicca refers to a type of disease characterized by a dry condition of the joint with a preponderance of osteal involvement. In the knee, elbow, and ankle the swelling takes on a peculiar fusiform shape accentuated by the atrophy of the muscles above and below the joint, the overlying skin assuming a blanched appearance and the superficial veins becoming distended. This peculiar condition has received the name "white swelling" or "tumor albus."

General Treatment.—A few general remarks will first be given on this subject. Constitutional treatment, as in all forms of tuberculosis, is most important. The patient's general health should be kept at the highest point. Good food and plenty of fresh air for the entire day and night are essential. The patient should sleep out of doors without fail. Adenoids and diseased tonsils must be removed. No drugs are necessary. Cod liver oil in winter is an excellent form of fat.

HELIOTHERAPY.—A new form of treatment as carried out in Switzerland has given excellent results and deserves a wider extension in America. It is the exposure of the entire body (excepting the head) to the sun's rays (heliotherapy) for as long a time as is possible every day, all dressings being removed from the affected joint. The following remarks are from an article on Heliotherapy by Henry Dietrich (5):

> "In 1903 Rollier established the first sanatorium for the systematic treatment of surgical tuberculosis at Leysin, Switzerland, and since then he has erected two more at the same place, so that he can now accommodate 450 patients. These sanatoriums are located respectively at altitudes of 1,250, 1,350, and 1,500 meters (about 3,800, 4,100 and 4,500 feet). Two hundred beds are reserved for children. Rollier in his address before the Gesellschaft deutscher Naturforscher und Aerzte in Munster in 1912 says: 'It is in surgical tuberculosis that we have seen the best results from heliotherapy, and we have made the treatment of it our life work. As a result of my experience in the use of the light-cure in higher altitudes, based on an experience of nine years, I maintain to-day that the cure of surgical tuberculosis in all its forms, in all stages, as well as at every age of life, can be accomplished. The closed surgical tuberculosis always heals, if one will only be patient, and above all if one understands how to keep it closed. To transform a closed tuberculosis into an open one means to increase the gravity of the case a hundredfold. A diminution of the vitality of the tissues is the inevitable consequence. . . . To regard a surgical tuberculosis as a local disease which can be cured by local treatment alone is a ruinous error. On the contrary, it is a general affection which requires general treatment. Of all infectious diseases it is the one in which the individual resistance plays a deciding part. Our first effort therefore is directed to improve general conditions and thus to bring about a healing of the local focus by treatment of the entire system. A rational local treatment is necessary as well, provided it is not too one-sided.'
>
> "Patients on arriving at the sanatorium are put to bed for a few days, even those whose local condition does not make this imperative. They are thus allowed to become acclimated to the altitude. After three or five days as a rule, they are pushed out onto the verandas into the sunshine. The head is covered with a white hat or an umbrella, the eyes protected with dark glasses and a white garment worn over the body. On the first day the feet are exposed three times a day for five minutes; on the second day three to five hours daily. This, as a rule, is the maximum, although some bear the three times ten minutes, and the legs to the knees three times five minutes; on the third day the exposures are increased five minutes three times daily; on the fourth

day the thighs are included; on the fifth day the arms; on the sixth day the back and on the seventh the abdomen and chest, so that at the end of the first week some parts of the body are exposed for one and one-half hours per day. The exposures are increased five minutes three times daily until the patient gets a full sun-bath for from three to five hours daily. This, as a rule, is the maximum, although some bear the treatment for seven hours. Individualization of course is necessary, and in some instances the scheme of exposures must be modified to suit the case. Pulse and temperature are closely watched and used as an indicator of the patient's tolerance.

"Rollier has discarded the use of all non-removable appliances for immobilization, as antagonistic to the principles of heliotherapy. By their use, no matter how skillfully made, the activity of the skin is greatly reduced; exposure to sun and air is impossible, metabolism decreases, and atrophy results. These factors tend to prevent healing and, if healing does take place, the functional result is, in many cases, a poor one. All appliances for immobilization are therefore removed daily during the period of exposure, except occasionally in the case of very refractory children with spondylitis. In these cases he cuts large fenestra into the jackets. In general he applies extension apparatus, splints, bandages, and removable corsets of celluloid. In many cases of spondylitis, a corset or jacket made of heavy material, which is in turn fixed to the mattress, is employed. Ambulatory appliances, usually made of celluloid, so that they can be removed and treatment continued at home, are used only after the tuberculosis is healed, to protect the newly formed bone.

"Medication is rarely resorted to; children, however, receive cod-liver oil.

"Cold abscesses, unless interfering mechanically, are given ample time to become absorbed. This occurs in a percentage of cases. Under all circumstances the rupture of an abscess is to be prevented, as a mixed infection is practically unavoidable and makes the prognosis so much worse. If necessary, they are aspirated and injected with iodoform, 10 per cent., in oil or glycerin, to guard against mixed infection. This is done even daily, if necessary; every means and effort are used to avoid spontaneous rupture. If the patient has or develops a sinus, it is covered, when not exposed to the sun, with an alcohol dressing to prevent infection as much as possible. Sinuses, no matter where located, when exposed to light, first show an increased secretion, then gradually dry up, the granulations become healthy and complete healing is frequently seen. According to Bernhard, the scars resulting are firmer, yet more elastic, than when heliotherapy is not employed, and consequently produce less contraction."

The application of the treatments to specific seats of the disease is in substance as follows:

TREATMENT BY HELIOTHERAPY IN VARIOUS FORMS OF TUBERCULOSIS

SPONDYLITIS.—These patients are put to bed and immobilized as mentioned before. Children, if they wear a jacket, have a large fenestrum cut anteriorly, as the vertebræ in children are not much further removed from the surface of the abdomen than from the back. A gibbus, if present, is padded with cotton or a pillow, or, more frequently, the patient is placed on the abdomen with a triangular pillow under the chest. The position increases lordosis and prevents, or when present, decreases the gibbus. After healing is verified by roentgenoscopy, a celluloid corset is worn. These cases require from one to two years.

COXITIS.—An extension is applied in bed and the pelvis is elevated on a pillow, to expose the entire coxofemoral trochanteric region to the sun. At the same time this avoids contractures. Abscesses when not absorbed are aspirated. The treatment requires at least a year, but splendid functional results are obtained.

LYMPH-NODES.—Bronchial lymph-nodes, lymph-nodes of the neck, have yielded beautifully to this treatment. In some cases the enlarged lymph-nodes disappear spontaneously. In others it becomes necessary to operate; but even when there are sinuses the end-results are good, and the scars as a rule are less disfiguring than in operative cases, complicated by infection. The treatment is continued from six months to two years.

Tuberculosis of Peritoneum and Ileocecal Tuberculosis.—Even in these cases, the prognosis as a rule is good. Under the influence of the sun and fresh air, the pain soon subsides, exudates in the abdomen become absorbed; large tumor masses in the ileocecal regions, which were declared inoperable by Roux, disappeared, and healing took place.

Genito-urinary Tuberculosis.—The principal effects of heliotherapy in these sad cases is the lessening of pain and the amelioration of distressing bladder symptoms. Tuberculosis of the hands and feet offers an especially good prognosis.

Closed tuberculosis of the pelvic bones is amenable to this treatment, but a mixed infection in cases of sacro-iliac tuberculosis makes the case practically a hopeless one.

Patients with a combined local tuberculosis and tuberculosis of the lungs often show a marked improvement of the condition of the lung. As Rollier, by his method, exposes the thorax last, he has seen no ill effects such as hemoptysis. He says that bad effects, such as congestion of the head, nausea, apoplexy, etc., are seen only when the method is improperly used and we fail to individualize.

Rollier's results have attracted attention the world over, and such men as Bardenheuer, von Eiselsberg, Escherich, Kocher, and others have written enthusiastically about the work at Leysin. Bardenheuer, who had very radical views on the treatment of surgical tuberculosis, now rarely resorts to a resection. He says, "Resection of a joint is a mutilating operation compared to Rollier's results."

Non-Operative Versus Operative Treatment

Regarding conservative (or non-operative) treatment versus radical (or operative) procedures, Ely has this to say:

"Our two main rules for treatment are: 1. Deprive the joint of function. 2. Avoid secondary infection."

"Radical operations on children's joints are often ineffectual, because lymphoid marrow is found in the shafts, and we have no way of telling just how far the disease has spread. These operations cause unsightly and crippling deformities by interfering with the centers of growth in the ends of the bones, and the testimony of those who have practiced conservative treatment is to the effect that tuberculous joints in children can often be cured thus with function. Again, it is possible to carry through with a child a long course of treatment that would be impracticable for an adult. Therefore, in children the treatment is almost invariably conservative. We carry it through in the face of almost every obstacle until all hope of saving the limb is gone. Then we amputate to save life. Beginning amyloid degeneration, or a prolonged septic absorption may demand amputation. In adolescence we adopt conservative treatment until growth is finished, or almost finished. Then, if the disease is not well, we adopt the measures suitable for adults. Conservative treatment is rarely if every successful in adults, and is almost impossible to carry out. Under the best circumstances the only thing we can possibly hope for is a stiff joint. This we can attain by operation in a few months, and can certainly cure the disease. Therefore, Ely maintains that the treatment of a tuberculous joint in an adult is almost invariably radical. Bearing in mind, however, the statement of some authorities that occasionally the milder forms recover under conservative treatment, and bearing in mind the fallibility of our diagnosis, it is often well to try conservative measures for a few months. Then, if the joint is not much improved, and if we are sure of our diagnosis, radical treatment is in order. The object of conservative treatment is to deprive the joint of function temporarily; the object of radical treatment is to destroy the function in the joint, to deprive it of function permanently."

It may be worth while to try tuberculin injections although opinions of authorities differ as to their value.

Bier's treatment by passive hyperemia is advocated by many authorities, although it does not seem to have held its own in the long run. It is, however, worth a trial as it certainly can do no harm.

In adults the social condition of the patient will make a difference in our treatment. In the well-to-do, to whom time and money are secondary considerations, conservative treatment may be more readily adopted. Three to five years may be necessary for a cure. In the poorer classes operative treatment should be employed early since the time required for a cure, in many cases not more than six months, will thereby be materially shortened. In either case the joint function will be permanently damaged.

For the conservative or non-operative treatment of individual joints see Albee's article on that subject.

Operative Treatment.—Aspiration followed by injection of various solutions into the joint has had a great vogue, but does not seem to rest on a firm scientific basis (Ely), since nothing we can inject into a joint will have any direct effect upon tubercles in the marrow or in the substance of the synovial membrane, or upon dead bone or cartilage. These injected substances may act, however, by irritating the joint tissues, thus producing fibrous tissue. A 10 per cent. emulsion of iodoform in glycerin seems to be the favorite solution employed (see under Puncture and Aspiration of Joints).

TREATMENT OF COLD ABSCESSES.—The great object is to prevent these abscesses from becoming secondarily infected. If small, they are left absolutely alone. If larger, or causing pressure symptoms, they should be aspirated, and, when they fill up, they should be aspirated again. After a few such repetitions the abscesses will usually cease to fill. A bottle aspirator with a very large aspirating needle is advisable to prevent the entrance of air. The abscess cavity is then partially filled up with a 10 per cent. iodoform emulsion with glycerin.

The psoas abscesses of Pott's disease should be aspirated at a point one inch internal to the anterior superior spine and an inch below it. The abscess can be distinctly palpated. It pushes the intestines upward. Postpharyngeal abscesses should never be opened through the mouth on account of the certainty of their becoming secondarily infected. They are best attacked from the side of the neck.

INFECTED COLD ABSCESSES.—We can often heal up the abscess if we can overcome the secondary infection. To do this we inject the sinus with some form of paste, following out Beck's idea. There have been a number of deaths due to the bismuth contained in this paste so that if the cavity to be filled up is a large one, it would be wiser to omit the bismuth altogether or to decrease the amount of bismuth and to substitute the subcarbonate for the subnitrate of bismuth. Blanchard, of Chicago, recommends white wax, 1 part, vaselin, 8 parts, to be mixed while boiling. The paste is treated in a water bath until it is fluid, and is then injected with a glass syringe, with considerable force, into the opening in the sinus, so as to fill up every nook and crevice of the tract. No paste should be used if the Röntgen-rays show the presence of a sequestrum.

GENERAL REMARKS ON OPERATIVE TREATMENT OF TUBERCULOUS JOINTS.—The finger or toe joints in an adult, when thus affected, are best treated by amputation (Ely). The possibility of grafting a toe joint into a finger joint should be considered.

In the hips the usual operation is an excision. Ely says that the disease can be cured by producing an ankylosis (see Albee's ankylosing operation), or by removing just enough of the head of the bone to produce a dislocation. In either case the joint is destroyed. The former operation gives a result better for walking, the latter for sitting. In extreme cases an excision will be required.

In the spine the best procedure is the bone grafting operation devised by Albee (which see).

TUBERCULOSIS OF OS CALCIS.—In order to eradicate the disease we should never infect the neighboring joints. If the focus can be removed without this infection, then it should be done and all sequestra should be removed. The bone cavity may be filled with Beck's paste or the Bier treatment may be used. Occasionally resection of the os calcis will be necessary. For this see under Resection of Ankle.

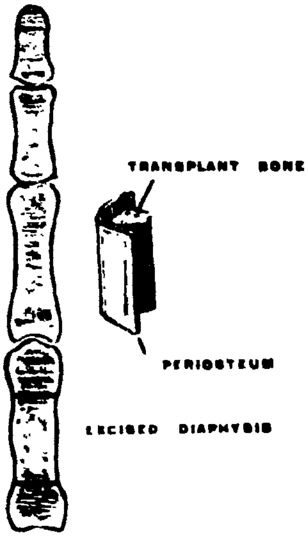


FIG. 2. TRANSPLANT FROM TIBIA. Periosteum overlapping the bone into the space left after excising the diaphysis of phalanx for spina ventosa.

SPINA VENTOSA.—This should be treated by transplanting a bone with its periosteum into the defect made by removing the diseased diaphysis (with its diseased periosteum) (Fig. 2). The diseased bone and periosteum are laid bare and removed, avoiding injury to or opening of the joints, as well as damage to the epiphyseal lines (in the metacarpals this is in the distal extremities, in the phalanges at the proximal ends). The defect is filled in by a piece of bone taken from the anterior aspect of the tibia, which is slightly longer than the defect itself. The periosteum is cut larger on the sides and ends than the bone itself, whose lateral edges it should overlap. Considerable traction should be exerted upon the finger and the graft wedged in tightly into the defect. The periosteum overlapping the ends of the graft is sutured to the periosteum of the old stumps, a splint which extends out beyond the end of the finger is applied on the palmar aspect, and this should be kept for five weeks. In children the subsequent stiffness of the finger will disappear of itself by use. The functional and cosmetic results are excellent.

Chronic Gonorrheal Arthritis

A new and very hopeful chapter has been opened up recently in the treatment of these often severe and very obstinate cases. It is that of drainage of the seminal vesicles. Those interested are referred to the work of Eugene Fuller and to a recent article by J. Bentley Squiers (15), from which the following extracts are taken. The recent contribution of Billings (1) on "Chronic Focal Infections and Their Etiologic Relations to Arthritis (and Nephritis)" has definitely established the internal relationship between localized suppurative processes and metastatic arthritis. Among the many focal points productive of joint manifestations are the seminal vesicles. Billings has scientifically proved that "there can be no question that chronic gonorrheal infection of the seminal vesicles may cause systemic disease, especially arthritis, and streptococcus infection of the seminal vesicles may also cause systemic infection and arthritis deformans." Squiers believes that the exciting cause is in the nature of a mixed infection. This would explain why we have so many chronic arthritides, popularly designated "rheumatoid joints," which are not specifically neisserian, but are the late result of an antecedent gonorrheal infection with an engrafted pyogenic element. From the focal point of infection in the vesicle we have the periodic absorption of infective material, either neisserian or streptococcic, staphylococcic, or both, or colon bacilli, with the subsequent development of single or multiple arthritis, either in the form of a chronic ostearthritis of hypertrophic or atrophic type. In many of these cases massage of the seminal vesicles will prove of very little curative value because of the inadequate drainage, due to the cicatricial tissue. In cases of either type, where all means of treatment have been tried and failed, incision and drainage of the entire seminal vesicles should be practiced and the results have proved nothing short of remarkable.

Incision and Drainage of the Seminal Vesicles.—Squiers has perfected the technic of Fuller so that the vesicles are brought into direct view. His method is as follows: The patient is in the extreme lithotomy position. The incision is an inverted Y which divides the skin and exposes the median tendon of the perineum. This tendon is divided, and the fossæ on either side are opened by blunt dissection down to the prostate. The urethrorectalis muscle is divided and the prostate is exposed. Two stout silk sutures are now introduced through the prostate and bladder wall at the junction of the prostate and bladder base. They are placed as far laterally as possible. Traction on these sutures downward and forward rotates the prostate and bladder base upward and forward, thus exposing the fascia covering the vesicles (fascia of Desonvillier). This fascia is divided and the vesicles present. Incision and drainage with multiple puncture of diverticula or excision of the vesicles are then readily accomplished. In excising the vesicles a ligature need only be placed at the superior external pole, at which point the blood vessels enter, the rest of the vesicle is enucleable. Excision is made possible by cutting through the vesicle proximal to this ligature. If drainage only is done, a rubber drainage tube is placed in the vesicle and the soft parts are sutured about it. This tube is left in for a week.

SYPHILITIC ARTHRITIS

This is more frequent than is ordinarily supposed, and is usually treated under a wrong diagnosis. Syphilis occurs in the joints in two well-differentiated forms, which correspond to the synovial and bony forms of joint tuberculosis. Charcot's joint is likewise a result of syphilis. The rarer form of syphilitic arthritis is a synovitis which occurs in the tertiary stage. The joint is distended and contains fluid, with but little pain and disturbance of function. A positive Wassermann in the absence of other syphilitic lesions calls for the administration of mercury and possibly salvarsan. The results of such treatment are usually prompt and satisfactory.

A surer and more frequent form of syphilitic arthritis is that in which there is a proliferative inflammation of the marrow and of the inner layer of the periosteum of the bone end. It is either multi-articular or uni-articular in about equal proportions. Ely says that this type is often a manifestation of hereditary syphilis, occurring in children or adults. It may lead to sinuses developing. Immobilization is useless. Mercury, salvarsan, and the iodids are our sheet anchors.

ARTHRITIS DEFORMANS

Arthritis deformans occurs under Type I, and is characterized by a proliferation of the synovia and of the bone marrow, by atrophy of the bone (either a rarefying osteitis or a resorption of calcium salts), and by erosion and destruction of the cartilage. Ely mentions a group of affections of joints which were thought to be one definite clinical entity, so called "arthritis deformans." He says that probably a number of different agents are responsible for them, almost always an infection. He believes that any micro-organism which can cause an acute arthritis can cause a chronic one. Whether the organism itself must be in the joint, or whether, located in some other organ, it can elaborate toxins which cause the arthritis, is not settled. Trauma probably acts as a direct exciting cause, in the same way as in the acute cases. Between the slight synovial involvement and the severest cases of chronic arthritis of this group the difference is merely one of degree, as the difference between a mild synovial tuberculosis and a destructive joint tuberculosis is merely one of degree.

The proximal interphalangeal or metacarpophalangeal joints are often the first to be affected. The joints are from the start in flexion and are swollen. This swelling later on disappears, leaving the joint shrunken, often with a distinct constriction at the articular line, this being due to the secondary shrinking of the synovia, and to the atrophy of the articular cartilage. Motion is restricted almost from the start, and bony ankylosis sometimes occurs. Flexions and subluxations of the diseased joints are often present and may be persistent. The Röntgen plate shows a thickened synovial capsule, a thinning and erosion of the cartilage, and an atrophy of the bone.

The prognosis formerly used to be bad; now it is not so hopeless. If we can find a cause (an infectious agent), we may accomplish much by vaccines (see under Acute Infectious Arthritis). All hidden foci of possible infection should be eliminated.

If, after careful study, we can find no focus, we must fall back upon empiricism. Vigorous antisyphilitic treatment should be carried out for 6 months. Failing in this, we may administer extract of thymus gland (powdered extract, 10 grains, 3 times a day).

During the acute exacerbations rest is advisable, the painful joints being put on splints. It is important to keep the affected joints in such a position that, if ankylosis result, they will be in the best attitude for function. Thus the knees should be kept in complete extension, the elbows and ankles in a right-angled flexion.

During the remissions the patients should get about, if necessary, the affected joints being supported by a brace which allows of some motion. Passive motion to the limit of toleration should be employed as well as massage and exercises by the Zander apparatus.

Operative treatment is rarely indicated except in joints, such as the knee, where hypertrophied fringes may have developed and mechanically interfere with function. In these cases one may open the joint and trim away the fringes.

The second type of arthritis is characterized by inflammation and degeneration of the synovia, and degeneration of the marrow, and by resulting hypertrophy of bone and cartilage. Under this heading are included cases heretofore described as ostearthritis, the hypertrophic form of Goldthwaite, Heberden's nodes, morbus coxæ senilis, etc.

Concerning the etiology, we know little that is definite. The changes found in this type are often simply exaggerations of those ordinarily taking place in the joints as age advances. Infection probably plays a great rôle. Disturbed metabolism is a convenient term, but it simply expresses ignorance. The influence of trauma is greater in this type than in Type I.

An internal derangement of a joint (displaced semilunar cartilage, an intra-articular fracture healed with marked deformity) may occasion an arthritis. A severe single trauma, especially in the hip, seems clinically to be the starting point of the disease. Persistently occurring traumata received in certain occupations cause many of the cases. In this class would come the stiffened spines found in pursuing laborious occupations. Some explain the changes in the joints of such persons as the results of Nature's efforts to relieve the muscular strain. The coal-trimmer's elbow is another example.

Subluxations in the joints may occur. The cartilaginous edges hypertrophy and they may be transformed into bone, causing spurs and exostoses which interfere with motion. Flexions as well as lateral distortions occur, these lateral distortions being characteristic of the disease. The nodular bone formations in the terminal joints were first described by Heberden and are called Heberden's nodes. The nodular lesions of the fingers in Type II are usually of the terminal phalangeal joints and produce lateral deformities, while those of Type I are of the metacarpophalangeal or proximal phalangeal joints, are fusiform, later often shrunken, and cause flexion deformities. Portions of the proliferated cartilage may be torn loose, forming "joint mice." Adhesions never form between the opposing joint surfaces, and bony or fibrous union never takes place. The obstruction to motion is purely mechanical.

Treatment.—The constitutional treatment is important. All digestive disturbances and derangements of the viscera should be corrected. A purin-free diet should be used. Elimination should be promoted by cathartics (particularly phosphate of soda), by flushing the colon, and by hydrotherapy. All sources of infection should be inquired into, and, if any be found, it should be eliminated, as in Type I.

LOCAL TREATMENT. In this type of arthritis, in contradistinction to Type I, passive motions, mechanotherapy, etc., are absolutely contra-indicated, since such motions will injure the joint directly, by grinding together the rough, bony, and cartilaginous surfaces, and by wounding the soft parts. Rest and protection should be afforded by a brace which permits motion within painless limits. Bakings may be found useful. If the joints be very painful, they may be immobilized for a time with plaster-of-Paris.

Operative treatment may occasionally be advisable, such as the removal of a spur interfering with motion, or the removal of a "joint mouse." Often a stiff, ankylosed, painless joint is much better than a slightly movable painful one. A resection should then be done with the idea of stiffening the joint. Albee has devised such an operation for the hip (which see).

Chronic Arthritis of the Spine

This disease can be generally divided into the two types previously described, and overwhelmingly preponderates in the male sex.

The general lines of treatment have already been gone into, namely, removal of the cause of infection, if that be possible, in addition to rest and protection. Forcible mobilization should not be used. To prevent deformity and relieve the pain a well-feeling spinal brace or jacket should be worn.

CHARCOT'S OR NEUROPATHIC JOINT

This occurs in tabes dorsalis and syringomyelia, and is probably produced by the late syphilitic toxins. The joint becomes loose, subluxated, and wobbly, and is distended with fluid.

Treatment.—Conservative treatment is probably the best. The patient may go about for years comfortably with a well-fitting brace. Resections may be done to stiffen the joints, with good success in the ankle but with poorer results in the knee. The joints may likewise be stiffened by grafting into the two bones making up the joint living bone with periosteum taken from the tibiæ. In patients of the working class an early osteoplastic foot amputation is advisable, all means being taken to see that the os calcis heals firmly to the tibia and fibula.

HEMARTHROSIS

Effusion of blood into the joints in hemophiliacs is not at all uncommon, the knee being probably the most frequently affected. It occurs even after a slight injury or no injury at all.

Treatment.—The limb should be put at rest on a splint in the elevated position, the patient being recumbent, and an ice bag or evaporating lotions should be applied. The general treatment of hemophilia is unsatisfactory, but one should administer lactate of calcium in ten- to twenty-grain doses three times a day, with the hope of increasing the coagulability of the blood. Normal horse or human serum should be administered for the same purpose. Massage and aspiration should be avoided on account of the danger of increasing the bleeding. Passive movement must be very gradually and cautiously employed after the effusion has disappeared. When frequent effusions occur into joints, osteoarthritic changes are very likely to take place.

ARTHRECTOMY AND EXCISION OF JOINTS

Arthrectomy is used as meaning the removal of synovia either alone or plus excision of the diseased portions of cartilage and bone by spooning or with chisel. The hoped-for ultimate result is the retention of motion.

Excision (or resection) is reserved for operations where the whole articular surfaces are systematically removed. The expected result is ankylosis.

Arthrectomy has a very limited application. In general it may be said to be the operation of choice in children, if any be performed, on account of avoiding injury to the epiphyses, which would occur in an excision. The difficulty in many joints is to get sufficient exposure to remove all the synovia without removing some of the bone, e. g., hip.

Excision or resection is the operation of choice in adults. The result in general to be expected is ankylosis, as in knee, wrist, and ankle, or impaired motion, as in hip, elbow, and shoulder.

The use of a tourniquet has caused considerable difference of opinion. The subsequent oozing, due to the vascular paralysis, is a great disadvantage. I prefer to operate without a tourniquet, clamping all vessels as I proceed. In any muscular paralysis. A *broad* band should be employed.

In all joints where we hope to subsequently obtain useful motion, as in the case a *narrow* rubber tube should not be used, as this may cause subsequent shoulder, elbow, and hip joints, we must seek to preserve all the ligaments and muscular attachments possible. This is best accomplished by chiseling their insertions away. If this be not possible, then the attachments, together with the periosteum, should be lifted up from the bone beneath, of which is removed as much as is necessary. After this the periosteum is replaced and the muscles sutured to the bone in their proper relations to each other. By this method in the shoulder and elbow joints, after such a subperiosteal resection, and with proper after-treatment, a very satisfactory and powerful motion may be attained.

Excision of Hip

The incisions which may be employed in excision of the hip are:

A. Anterior straight incision—Barker's operation (Fig. 3).

B. External or Langenbeck's operation—König's method. This is probably the best (Fig. 4).

C. Posterior angular incision—Kocher's operation (Fig. 5).

D. Total extracapsular resection (Bardenheuer).

Each of these methods has its own special merits and may be used according to different circumstances.

Other methods are:

Larghe's high curved incision.

Ollier's snuff-box method.

Anterior Straight Incision—Barker's Operation (Fig. 3).—This is the most satisfactory method for children, since there is much less danger of damage to the epiphyseal line of the great trochanter. There is practically no division of muscles. The incision begins ½ inch below the anterior superior iliac spine and runs downward and slightly inward for about 4 in., opening up the groove between the sartorius on the inner side and the tensor vaginæ femoris on the outer, these muscles being retracted out of the way. The external cutaneous nerve is retracted outward, if seen; as the incision is deepened, the transverse division of the external circumflex artery being ligated, the capsule of the joint is exposed and opened, parallel in line with the original incision, and on to the head of the femur. The cotyloid ligament is incised to allow entrance of air, which permits the head of the femur to be drawn down lower. The neck of the bone is divided with a narrow saw or a Gigli saw. The head is then seized with lion-jawed forceps and removed, after cutting the ligamentum teres. The most important part of the operation is now to be performed, namely, the removal of

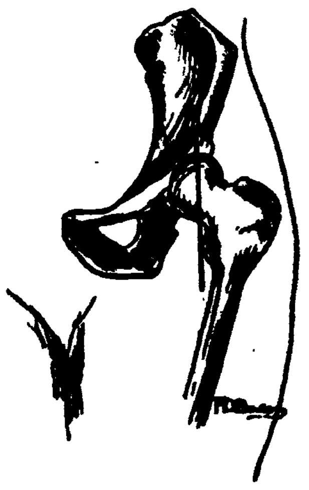


FIG. 3.—ANTERIOR STRAIGHT INCISION FOR RESECTION OF HIP.

the diseased synovial membrane. The capsular original incision is defined and the tissues in front of it, upward and downward, are separated by the finger and raised until the margin of the acetabulum is reached, when the anterior margin of the capsule may be cut away almost entire. With good retraction the acetabulum is next cleared by gouge or scissors or curette, the remains of the ligamentum teres being removed also. The posterior portion of the capsule is next excised or curetted thoroughly. It may be impossible to do this well through the anterior incision. If the patient is standing the operation well, Cheyne and Burghard recommend that a second incision be made behind the trochanter, running upward and backward from its posterior border in the direction of the fibers of the gluteus maximus, which are bluntly separated. The dissection is deepened until the posterior portion of the capsule is reached, which is separated from the posterior structures by a finger in the posterior wound and another in the anterior wound. A considerable portion of the capsule may thus be cut away. The wound is irrigated and a rubber tube is introduced through the posterior incision for drainage. The remainder of the posterior wound, as well as the anterior, is sutured completely. The limb is brought to a position of abduction, the adductors being divided close to the pubis, if thought necessary.

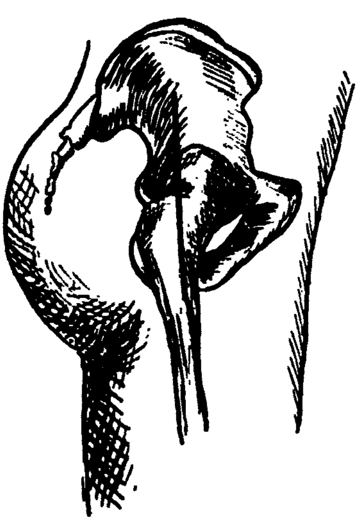


Fig. 4.—External Straight Incision. Langenbeck's Operation for Resection of Hip.

AFTER-TREATMENT.—Extension should be applied, a weight of 3 or 4 pounds being used for a child. The limb should be in abduction and rotation prevented by a suitable apparatus. The patient should be prevented from sitting up. This treatment should be continued for six weeks, then a double Thomas' splint should be applied, when the patient can get about on crutches with a high boot on the sound side. No weight should be allowed on the operated side until 6 or 8 months after the operation. If a movable joint is desired, limited passive motions of the joint should be given twice a week after the wounds are healed.

External Straight Incision or Langenbeck's Operation—König's Method (Fig. 4).—This method is particularly advisable in adults when the disease extends far out along the neck of the femur, and particularly when there are several sinuses. It is probably the most frequently used method, although there is considerable interference with muscles.

The incision is about 5 in. long and runs over the middle of the great trochanter in line with the long axis of the femur. About half of this incision lies above the trochanter. It is carried down through the gluteus maximus. The gap between the gluteus medius in front and pyriformis behind is identified and the muscles separated and then retracted. The capsule of the joint and the periosteum of the great trochanter are divided to the bone in the line of the original incision. The trochanter in young subjects is usually cartilaginous and the epiphyseal portion may be divided vertically in two with the knife. These portions retain their muscular attachments above and below and are connected with the femur by periosteum. The two portions are retracted aside. In adults, with a broad chisel cut off a shell of bone from the anterior and from the posterior margins of the trochanter. Leave these shells loosely attached to the shaft of the femur, being hinged by the periosteum and soft tissues. These shells bear the insertions of the trochanteric muscles, or the muscles may be separated from the trochanter subperiosteally. This last is not so good a method as the one preceding. The remaining portion of the trochanter between these two shells must be removed flush with the femoral neck by means of the chisel. Expose the neck of the femur and bare the bone with the periosteal elevator. Divide the neck with a finger saw, or, better, a Gigli saw. The neck and head are seized with lion-jawed forceps and gradually extracted. The removal is much facilitated by incising the capsular ligament freely and admitting air into the joint. This may permit division of the ligamentum teres, if it be still intact. Another plan is, after dividing the ligamentum teres, to dislocate the head out into the wound before its division. If by reason of bony ankylosis it be difficult to remove the head in one piece, there is no objection to chiseling it out of the acetabulum. In unusually difficult cases one may chisel away a portion of the posterior rim of the acetabulum, which will allow of the introduction of a strong periosteal elevator, which will permit of the prying out of the head. The point where the bone is sawed will depend upon the amount of disease present. The usual point is at the junction of the neck and the shaft.

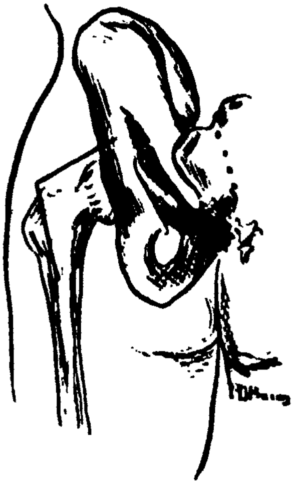


FIG. 5. POSTERIOR ANGULAR INCISION KOCHER'S OPERATION FOR RESECTION OF HIP.

Sufficient of the posterior superior cotyloid rim should be removed to allow of free inspection of the cotyloid cavity. All diseased parts should be removed with chisel and spoon. In cases where disease has invaded the pelvis and caused iliac abscess, the latter must be independently opened above Poupart's ligament and cleared out.

Remove all the diseased synovial membrane, particularly the pouch which runs down to the lesser trochanter. Attend to sinuses. Drain the remainder of the wound with tube and suture. The cavity may be filled with bismuth paste if thought best.

Posterior Angular Incision—Kocher's Operation.—The incision (Fig. 5) begins at the base of the external aspect of the great trochanter, then passes upward and forward to its anterior superior angle, thence obliquely upward and inward to the line of the fibers of the gluteus maximus toward the posterior superior iliac spine. Split the tendon and muscular fibers of the gluteus maximus in their direction and separate them. Expose the gluteus medius at its insertion into the trochanter. Rotate the hip inward so as to make prominent the posterior angle of the summit of the trochanter. Find the groove between the gluteus medius and maximus above and pyriformis below, drawing them aside. Divide the capsule along the superior border of the pyriformis. Rotate the thigh outward and subperiosteally separate the gluteus medius from the outer surface of the gluteus maximus from the anterior border of the great trochanter, raising a thin layer of bone with these tendons with the chisel if possible. In the same way subperiosteally detach the pyriformis, obturator externus and gemelli from the inner aspect of the great trochanter and the obturator externus from the digital fossa. Rotate the thigh inward and clear the inner and posterior aspects of the great trochanter. Thus the head, neck, and great trochanter are free. Cut the internal cotyloid ligament to admit air, divide the ligamentum teres from behind, on the head of the femur while the limb is adducted, flexed, and rotated inward. The head is now dislocated through the wound by outward rotation and removed.

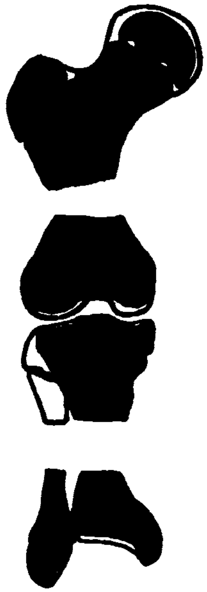


Fig. 6. — Epiphyseal Lines in the Vicinity of the Hip, Knee and Ankle Joints.

The remainder of the operation is completed as described in the preceding operations.

Regarding the operation of Kocher, Cheyne and Burghard say: By this operation the whole of the interior of the joint is very freely exposed and the thorough removal of the disease is perhaps easier by this method than by any other. It is, however, open to the serious objection that the glutei are considerably damaged, and the functional result is not likely to be so good; it gives excellent drainage, however, and should be employed by preference in cases in which numerous septic sinuses are present.

Ollier's Snuff-box Method—Binnie.—Flex the thigh to an angle of 45° and adduct so as to make the trochanter prominent. Make a semilunar incision, the lowest point of which is about 2 in. below the tip of the trochanter. This incision is continued in front of the trochanter 2 or 3 in. in a curve with the concavity upward and the same behind the trochanter. In front the incision is deepened between the gluteus maximus muscle and the tensor vaginæ femoris. Behind, the fibers of the gluteus maximus muscle are separated. The great trochanter is then separated obliquely so as to secure subsequent easy union. This is accomplished with a Gigli saw, passed around the trochanter, cutting outward and downward, or the base of the trochanter is cut through with a saw from without inward and upward, or the same division is made with an osteotome. Reflect upward the separated trochanter with its muscles, which will expose the joint thoroughly. Treat the disease as already described and finally return the trochanter to its normal position and fix it there by sutures of either wire or chromic gut, pegs, screws, or nails.

Operations on the Pelvis and Acetabulum with the Pelvic Edge Incision (Sprengel).—The indications for this method are cases of tuberculous coxitis, with acetabular or pelvic involvement, which are not benefited despite resection. Sprengel individualizes the cases and has indicated several methods by which the diseased areas may be freely exposed. With röntgenograms we can now better than previously locate the disease from the position of the fistulæ, from the use of the probe and rectal examination. From the results of these one of the Sprengel methods may be chosen:

1. Sprengel recommends his typical pelvic edge incision in case the disease is situated above and behind the acetabulum. The skin incision begins just in front of the posterior superior spine and follows along the iliac crest to the anterior superior spine. It divides skin and muscular origins down to the bone. From the front end of this incision the further incision curves in an angle downward and follows in the boundary between the tensor vaginæ femoris and the gluteus minimus to the trochanter. This triangular skin-muscle-periosteal flap is subperiosteally separated from the pelvis and reflected downward. The outer pelvic surface is thus freely exposed down to the incisura ischiadica major.

2. According to Sprengel, the above incision is not sufficient, if the tuberculous process has progressed, not only on the side, but forward from the acetabulum, particularly if flexion and adduction contractures have occurred in the hip. Sprengel then proceeds as follows: The operation begins with an incision over Poupart's ligament for the prophylactic exposure of the crural nerve, so as to make sure that it be not injured later. The incision then runs to the anterior superior spine and back along the crest. There occur cases in which the cicatricial soft parts, adherent to the pelvis, cannot be sufficiently retracted downward with this incision. Sprengel then adds an oblique incision to the first one, running from the anterior superior spine to the trochanter. For all foci lying on the outer side of the pelvis these Sprengel pelvic edge incisions furnish a free access and survey. After downward retraction of the flap, if necessary, the femoral head is resected, acetabular foci are chiseled away, extensions of the tuberculosis into the diploë are exposed and removed, after chiseling away the outer table of the ilium, etc. The contracted flexor muscles are finally transversely divided.

3. If the tuberculosis, after perforation of the acetabulum, has advanced to the inner side of the pelvis, then Sprengel advises the following procedure: An extensive vertical incision is made, according to the position of the anterior fistulæ, whose upper end lies above Poupart's ligament. Through this incision the crural nerve and the femoral vessels are exposed, to prevent subsequent injury to them. An oblique incision parallel to Poupart's ligament is added, joining the upper end of the vertical portion. Then one proceeds as in ligating

the common or external iliac. The abdominal wall is divided, the peritoneal pouch is pushed upward and inward, the fibers of the iliopsoas, or its remnants, are partly bluntly, partly sharply, separated and retracted until the internal side of the acetabulum is exposed and freed. The extent of the disease and the necessary procedures can be well ascertained. All diseased parts are removed with energetic use of the chisel and spoon. If a great defect of the acetabulum results, it is necessary that the soft parts on the outer side shall be sufficiently widely exposed. A part of the wound is closed with buried sutures, and the remainder packed.

Total Extracapsular Resection of Hip (Bardenheuer).—Sprengel's skin incision is used. The entire musculature on the outer side of the ilium, gluteus maximus, medius and minimus, and tensor vaginæ femoris are separated at their origin, at the edge of the sides of the sacrum, at the superior and inferior lines of the ilium, down to the upper boundary of the great sciatic notch. The flap thus fashioned, containing muscle, nerves, and vessels, is retracted backward. With inward rotation of the femur, one sharply divides the pyriformis, obturator externus, internus, and gemelli at the great trochanter, and the iliopsoas from the lesser trochanter. The psoas with the periosteum is now raised up from the visceral side of the ilium and the back of the acetabulum. A large, blunt, curved, fenestrated aneurysm needle is passed from the inside of the pelvis out through the great sciatic notch and a Gigli saw is drawn through, and the iliac bone is sawn through above the acetabulum higher or lower, depending on the extent of the caries. The pubic bone is divided with the chisel below the ileopubic tuberosity, and the ischium likewise is divided from the obturator foramen outward toward the lesser sciatic notch. Finally the femur is divided above the trochanteric line, so that more is removed from the outside than from the inside, in order that afterward the femoral shaft can be brought in the abducted position, where it should be nailed to the sawn surface of the iliac bone.

Results of Resection of Hip for Tuberculous Coxitis.—The goal arrived at in resections of the hip for tuberculosis is seldom a movable joint, but a joint ankylosed in a proper position. The functional results of Kocher's patients showed that they could walk for from two to four hours, mostly without pain or weariness. Most of the patients limped more or less strongly, half of them used a cane, but none used crutches. All patients could pursue their work well. The shortening amounted on the average to 4 to 8 cm. Flexure contractures were almost always present up to 30°; half of the cases had adduction contractures of, on the average, 20°.

Indications for Resection of the Hip.—Tuberculosis and acute osteomyelitis furnish practically all conditions calling for this procedure. The great majority of the German surgeons, in view of the better results obtained by the improved and simplified conservative treatment of hip joint tuberculosis, have again become conservative and only resect when the conservative treatment does not lead to a cure, or when there is severe bony involvement, such as wedge-shaped infarcts, great sequestra or perforation of the acetabulum, or when suppuration is very profuse, and when the general constitution is progressively becoming worse. Resection is more often indicated in adults than in children, since, in the latter, disturbances of growth of the limb occur and give very bad final results. A comparison of the indications in various clinics shows great diversity of opinion: thus Riedel resected in 89 per cent., and treated only 11 per cent. conservatively, while v. Bruns, of 387 cases, resected only 66, and treated 321 conservatively. The indications for resection have not only become more conservative, but the typical resection is not always performed, the procedure often being limited to atypical resections or removal of sequestra. De Quervain considers that in hip joint tuberculosis the only surgical treatment allowed is the removal of large sequestra. In the Bardenheuer acetabular resection we have now an operation with which we can extirpate tuberculosis of the acetabulum. The Bardenheuer (extracapsular resection) operation (which see) gives 8 per cent. better results with a smaller mortality (70 per cent. of cures with 4 per cent. mortality) than the hitherto "typical" resection operation. If, in spite of this, it has not been frequently employed, the reason is that one avoids so radical a procedure in the first resection, as Bardenheuer advises. By the use of the typical resection, with cleaning out of the acetabulum, König and Volkmann obtained 62 per cent. of complete healing. One will obtain a cure in over a half of the cases with conservative treatment. Besides these considerations, it is to be observed that with the perfection of the Röntgen rays we have now a means of localizing certainly the situation and extent of the tuberculosis. Only now does the Bardenheuer extracapsular resection receive its proper indication in some cases, and it is to be used only when the greatest localization of the tuberculosis is in the acetabulum and pelvis, in which case the so-called typical resection would not be sufficiently radical, that is, if the treatment of the acetabulum with spoon and chisel is not sufficient. This we can now determine absolutely by means of the Röntgen picture before the operation and resect immediately, according to Bardenheuer's method. Figure 6 gives the epiphyseal lines in the vicinity of the hip, knee, and ankle joints.

Excision of Knee

The term excision is here meant to refer to operations in which the entire articular surfaces are excised.

Numerous incisions are employed (see Fig. 10), as follows:

A. U-curved anterior transverse incision (Fig. 7 and Fig. 10, D). Probably the best incision is the U-curved anterior transverse incision (Textor). The convexity is downward, commences over the center of the lateral aspect of the joint, or at the posterior margin of one femoral condyle, runs down to midway between patella and tubercle of tibia, thence upward to the posterior margin of the opposite condyle.

B. Volkmann's transverse incision through the patella (Fig. 10, C). This

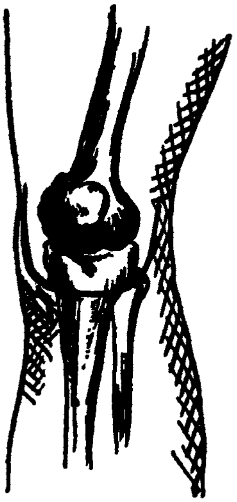


FIG. 7.—THE U-CURVED ANTERIOR TRANSVERSE INCISION FOR RESECTION OF KNEE JOINT (TEXTOR.)

incision is made from one epicondyle to the other, passing over the middle of the patella. The patella is divided transversely. This is the next best incision.

C. Kocher's external hooked incision (Fig. 10, A). This begins just below the middle of the tubercle of the tibia, runs outward, and then curves upward over the external condyle of the tibia, thence slightly outward and upward just in front of the external epicondyle of the femur.

D. Hahn's inverted U-shaped incision with convexity upward (Fig. 10, B). In this the quadriceps extensor muscle is divided.

E. Langenbeck's median vertical incision (Fig. 10, E). In this the patella is either split or retracted to one side.

F. Bardenheuer's extracapsular total resection.

U-curved Transverse Anterior Incision.—We will describe the procedure with the U-curved transverse anterior first.

The incision (Fig. 7 and Fig. 10, D) described above is deepened, cutting through the capsule and ligamentum patellæ. Divide the ligamentum patellæ through its center, so that the ends may be subsequently sutured. Turn the flap containing the patella upward. Further flex the joint and divide both lateral ligaments and both crucial ligaments. Bend the joint (Fig. 8) to more than a right angle, making the femur project through the wound. In youthful individuals, in whom excision is an infrequent operation, it is sufficient to smooth off the articular cartilage with a knife, but where it is ulcerated into the bone the tract should be chiseled or spooned away. A partial removal of the epiphyseal cartilage causes no essential disturbance in growth. In adults the typical excision is performed, sawing off bone from both the tibia and femur in such a way that the leg will be brought to a slightly flexed position with respect to the femur. Looked at from in front, the axis of the leg should lie in exactly the same axis as the thigh. In young individuals flexion should be avoided on account of the subsequent danger of its increase through muscular pull of the

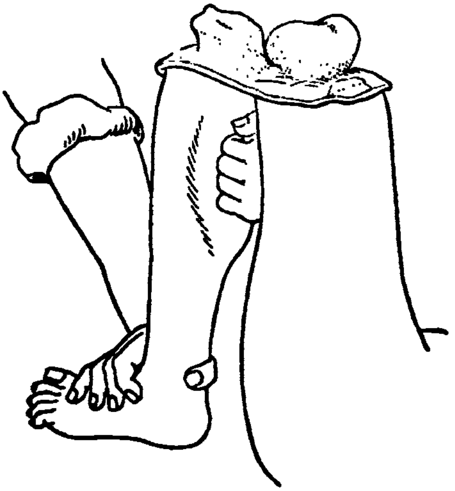


FIG. 8.—RESECTION OF KNEE. After division of the soft structures, the joint is bent to more than a right angle, making the femur, tibia and fibula project through the wound.

flexors. As little bone (Fig. 9) from the femur and tibia should be removed as possible and more should be removed from the posterior surfaces of the tibia and femur than from the anterior, in order to accomplish the flexed position. Only a superficial plate should be removed from the tibia. All foci of disease in tibia and femur should be sponged or chiseled out. All the synovial membrane should be most carefully dissected out, particularly that in the pouch beneath the quadriceps extensor, and all other synovial recesses should be similarly treated. With forceps or saw remove the posterior sharp edge of the raw surface of the femur. In all these procedures on the posterior surface of the joint remember the position of the popliteal vessels close to the posterior fibrous capsule. It is better to leave the patella in situ if it be uninvolved. If the articular surface be slightly diseased, the surface is removed with saw or forceps, or gouged away. If it be badly diseased, it is entirely dissected away. Fistulæ are all dissected out and the joint carefully revised. The ends of the bones should be accurately approximated, remembering that the divided surface of the tibia is much broader than that of the femur, and hence if the anterior margins of the two bones are brought into apposition, the posterior surface of the tibia will project markedly into the popliteal space, and, when the limb is placed upon the splint, serious pressure may be exerted upon the popliteal artery, and gangrene of the limb may result. Consequently the posterior margins should be accurately approximated, and some surgeons fix the bones in this position by a nail, wire or plate, while others content themselves with suturing the periosteocapsular sheath and fibrous tissue around the margins of the two ends. The divided ligamentum patellæ is sutured together. Drainage had better be omitted, but drainage tubes may be inserted in one or both posterior angles of the wound. Subcutaneous buried catgut sutures are passed and the skin closed with interrupted sutures. The limb is put up in a moulded anterior and posterior plaster-of-Paris splint in slight flexion. This will enable subsequent dressings to be done without disturbing the position of the bones. The patient is put in bed with the limb elevated and maintained so for several days. This relaxes the quadriceps and limits the oozing.

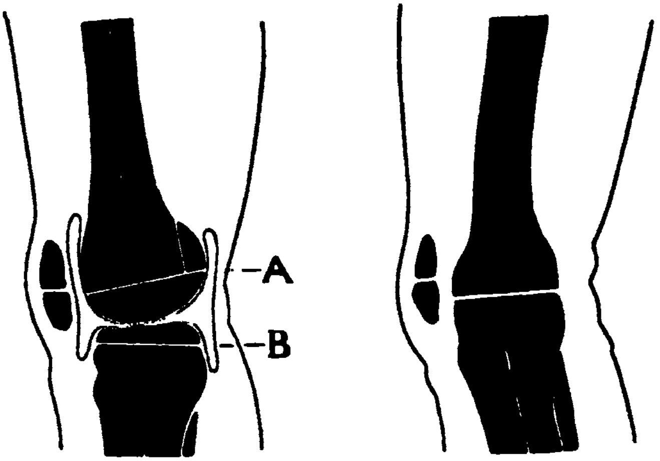


FIG. 9.—LINES OF DIVISION OF FEMUR (A) AND TIBIA (B) IN RESECTING KNEE. As little bone from the femur and tibia should be removed as possible and more should be removed from the posterior surfaces of tibia and femur than from the anterior, in order to accomplish the flexed position.

AFTER-TREATMENT.—Frequent dressings will be necessary for a few days on account of free oozing. Remove the tubes early, judging by the amount and character of discharge. Usually in about three months the patient will be able to get about. If union is solid, then no splints need be worn; if not solid, then a posterior splint should be worn until union is complete.

The use of a tourniquet during the operation is a matter of difference of opinion. Some surgeons do not use it, others, probably the majority, find it harmless and very useful. Many surgeons adopt König's plan of not loosening the constrictor until after the patient is returned to bed and the leg fixed in a high elevated position.

Kocher's External Hooked Incision.—This procedure (Fig. 10, A) follows the subcapsular periosteal method and endeavors to preserve the extensor apparatus intact. The lateral external incision begins a hand's breadth above the upper edge of the patella upon the vastus externus and runs perpendicularly downward, a finger's breadth from the outer patellar edge, and, below the tuberosity of the tibia, curves inward to cross the anterior edge of the tibia. The skin, fascia lata and, in the upper angle, the vastus externus are split, and, below, the external edge of the ligamentum patellæ and the tuberosity of the tibia are exposed. The tuberosity is subcortically chiseled free and, together with the ligamentum patellæ, is drawn internally. In the upper wound angle the joint capsule is opened at its reflection on to the femur in the upper pouch. Kocher lays stress upon separating the front end of the external meniscus from the crucial ligament, but leaves its connection with the capsule intact. It is also separated from the upper surface of the tibia. This is accomplished from the median line. The external meniscus and the front external part of the capsule are retracted externally. In the same way the front end of the internal meniscus is separated from the crucial ligament and, together with the capsule and the periosteum of the tibia, is separated from the tibia. The patella is inwardly retracted and the capsule is separated from the tibia internally and externally with gradually increasing flexion of the knee. The crucial ligaments are divided close to their insertions in the intercondyloid eminence of the tibia, or are chiseled free with a slice of bone still attached, and this division is continued to the posterior insertion of the menisci, which, in association with the crucial ligaments, are separated to the posterior surface of the tibia. All diseased tissues are extirpated and foci in the bone scooped out. If the disease has gone so far as to make sawing off of the bone ends necessary, that is, if one must proceed to a resection, then the crucial ligaments are divided at

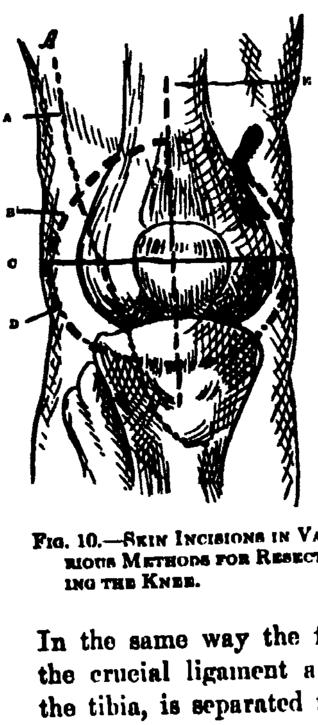


FIG. 10.—SKIN INCISIONS IN VARIOUS METHODS FOR RESECTING THE KNEE.

their upper attachment into the intercondyloid fossa of the femur, so that the connection of these ligaments with the menisci, the back wall of the capsule, and the periosteum are preserved. The capsule is split at the cartilaginous edge of the femur, and it is either extirpated or subperiosteally reflected backward until the origin of the lateral ligaments in the epicondyles is reached. The capsule, together with the periosteum on the back, is separated, and the femur is sawn off convexly and the tibia concavely. If a greater part of the femoral end be diseased and must be sawn off, then Kocher chisels off the epicondyles together with the lateral ligaments and these, in undisturbed connection with the periosteum, are reflected backward as far as the point where the sawn line comes through. The sawn bony surfaces are exactly approximated, but no fixation nails are used. Skin and fascial interrupted sutures are employed. Drainage may be necessary, but often is not. Plaster splint is used in full extension.

Kocher makes the following remarks on extensive resection of the knee:

> "The incision and the manner of subcortical separation of the attachments of the crucial, lateral ligaments, epicondyles, menisci, and the tuberosity of the tibia are made as previously described. If the capsule is diseased to the extent that one is certain, as in tuberculous synovitis and arthritis, that it must be removed in toto, whether the bony ends be removed, or not, the following method is employed: After the skin, vastus externus and the fascia lata are divided, the joint capsule is not yet opened, but it is dissected free from the outside on its entire upper and lower extent and the visceral sheet is separated from the bones, which on the femur is easily accomplished down to the cartilaginous edge. Then the entire capsule, as a connected mass, is separated from the cartilaginous edges of the femur, tibia and patella, and removed. In arthrectomy, in contradistinction to arthrotomy, the menisci are removed, since they are diseased and cannot be retained in separating the capsule above or below. If tuberculosis be the indication for operation, the most important point is the removal of the entire diseased tissues, synovial membrane, cartilages, menisci, and bones, as if it were a question of the removal of a malignant new growth."

Bardenheuer's Total Extracapsular Resection of Knee. A transverse incision is made over the middle of the patella from one condyle to the other, and to this are added two short lateral incisions above and below. The upper flap is dissected directly through the quadriceps tendon and muscle above the dome of the suprapatellar bursa; in the same way the lower flap is dissected down below the ligamentum patellæ. Then the dome of the suprapatellar bursa is dissected down bluntly to the immediate vicinity of the joint. If the capsule be accidentally opened, the opening is closed with forceps. The soft parts on the posterior aspect of the femur and joint are separated with the elevator from the capsule, while the periosteum is not touched. The femoral condyles are sawn obliquely from front to back, so that more is taken off from in front than from behind. The sawn surface of the femur is seized with a hook and drawn forward. The muscles and vessels in the back part of the joint are separated from the back part of the capsule. The heads of the tibia and fibula are obliquely sawn through so that more bone is removed from behind than in front. The sawn surfaces of the femur and tibia are nailed together and the skin wound closed.

Results of Knee Resections.—König was the first to show that disturbances in growth could be avoided by not impinging on the epiphyseal line (see Fig. 6). He gave exact measurements as to how much of the joint ends in children may be resected. In resections above the epiphyseal line there was found to be after 10 years a shortening of 25½ cm. Below the epiphyseal line, shortening was 13½ cm. after 6 years and 12 cm. after 4 years. In other cases the shortening amounted to 6 cm. after 12 years, 3½ cm. after 8 years, and 2 cm. after 6 years. In patients not resected, considerable shortening can result. König reported 3 cases in which, even after years, a shortening of 7 to 8 cm. was measured, even though no resection had been done. Haffa maintains that after resection below the epiphyseal line the shortening should not be greater than after conservative treatment.

Three patients of König's material developed after 3 years a flexed position so that the limb could not be used in walking. This flexed position is due to the fact that the limb, ankylosed in the knee, grows longer and is gradually drawn crooked by the unused, contracted and more powerful flexor muscles, just as the bow is curved by its tight tendons. Therefore, it is very important to anticipate the impending contracture by having the patient wear for a long time (till the growth is attained) an apparatus which shall maintain the extended position. Flail joints can be explained on several grounds. The first is a desire for a movable joint. The firmness requisite for locomotion cannot be attained with motion also. Ankylosis is also hindered by the use of antiseptics. Tampons between the sawn surfaces will prevent their consolidation. The bones must immediately be brought in contact in the most exact way. Helferich's arched sawing off of the ends furnishes many advantages, so that it can be considered the best method of sawing. The arched sawing is very conservative, since very little length is sacrificed, and there result two great congruent, bony, round, raw surfaces, which make possible a broad contact, and render impossible a subluxation of the tibia posteriorly. Still, with the transverse sawing, exceedingly good results are attained.

According to the views of many authorities, the correct position of the limbs is not the completely straight position, but a slightly flexed position, of about 165°. This is for walking, as for sitting, the best position. Klapp does not agree to this, since a previous slight flexion may lead later to a much increased flexion. Growing individuals must wear an apparatus for a long time to prevent this. If one will exclude with absolute certainty a contracture, the leg must be absolutely straight and thus be immobilized. A slight genu valgum is physiological.

In the resection for tuberculosis that method is the best by which an unimpeded oversight over the entire joint can be attained and the extent of the disease ascertained. One is thus in the best situation to operate most radically. Consolidation occurs in from one to two months. Splints should be worn for six months during which time no weight should be borne on the foot.

The results of resection of the knee are seen from Garré's statistics. Of 185 cases operated, 177 were resected, and 8 were synovialectomized. Of these 86 per cent. were cured and 8 per cent. improved; 4 per cent. of the resected patients had to be amputated subsequently. Shortening occurred as follows:

None in 17 per cent.
Of 1 to 2 cm. in 40 per cent.
Of 2 to 5 cm. in 30 per cent.

Contractures occurred in young patients in half of the cases. The function was good in 92 per cent. and bad in 7 per cent. In three-fourths of all cases the knee was in the straight position. Small amount of flexion (not over 170°) occurred in 12 per cent. Everything considered, in 85 per cent. the result was excellent.

Excision of Ankle

To excise the ankle joint, one may proceed in several ways: either temporary resection of the malleoli or removal of the astragalus is essential in order to obtain free access to the posterior part of the joint. Some surgeons prefer one, some the other. Cheyne and Burghard prefer the excision of the astragalus and express the opinion that this gives the best result, both affording the completest removal of the disease and giving an excellent functional result, a freely movable joint being practically always obtained. In addition, the astragalus is commonly the primary seat of disease and small subcartilaginous deposits may be overlooked if the bone be left behind. The epiphyseal lines in the vicinity of the ankle joint are given in Figure 6.

Excision of Ankle with Removal of Astragalus.—Two incisions are used. The inner one commences just over the anterior border of the tibia, runs down in front of the internal malleolus and curves slightly inward toward the internal cuneiform. On the external side the incision runs in front of the external malleolus, curving slightly toward the base of the fourth metatarsal bone. These incisions are deepened until the capsule of the joint is reached. The soft parts are carefully raised forward from the capsule behind with a periosteal elevator, which is pushed forcibly upward and downward, and all the soft parts are thus raised, exposing the capsular attachments to the tibia above and to the astragalus below. The anterolateral attachments of the soft parts are likewise separated from the malleoli. The attachments of the capsule to the tibia, the malleoli, and the tarsus are cut through with a knife and the anterior part of the capsule is removed in one piece. The lateral ligaments are now divided. The astragalus is then removed as follows: The inner incision being retracted, the astragaloscaphoid ligaments are divided. The foot is everted and the astragalus is pushed up, when a knife is insinuated beneath the bone and the calcaneoastragaloid ligament is divided. The astragalus is now held only at its posterior part by the sheath of the flexor longus hallucis, which runs in a groove in the bone; this sheath is divided and the astragalus is removed. The interior of the joint is now freely exposed and the synovial membrane removed from the lateral and posterior aspects of the joint. The tendon of the flexor longus hallucis gives rise to some difficulty, but by pulling the foot downward from the leg it can be seen and avoided. The lower ends of the tibia and fibula are protruded through either wound and carefully examined. In all cases the edges of the cartilage, to which the synovial membrane was attached, should be shaved off cleanly with a knife. Any soft or loose portions of cartilage should be removed, and the bone beneath gouged or chiseled away. Should there be any depressions in the cartilage, they should be enlarged and bone deposits looked for. The cartilage may be entirely chiseled away and with it a depth of bone, depending on the amount of disease found. The deep parts are stitched, drainage provided for, and the skin closed. The leg is put up in a posterior and anterior moulded plaster-of-Paris splint, the foot being at right angles to the leg. This should be employed for six weeks, when an apparatus (such as Hessing's splint) is applied, with the object of permitting movements at the joint but preventing lateral displacement, and also keeping the foot off the ground. The patient should not be allowed to bear weight on the sole until six or eight weeks have elapsed from the time of the operation. The chief difficulty after such an arthrectomy, or excision of the ankle, is the tendency to lateral deviation of the foot, particularly inversion, and this must be prevented by the use of apparatus until the parts have become firm.

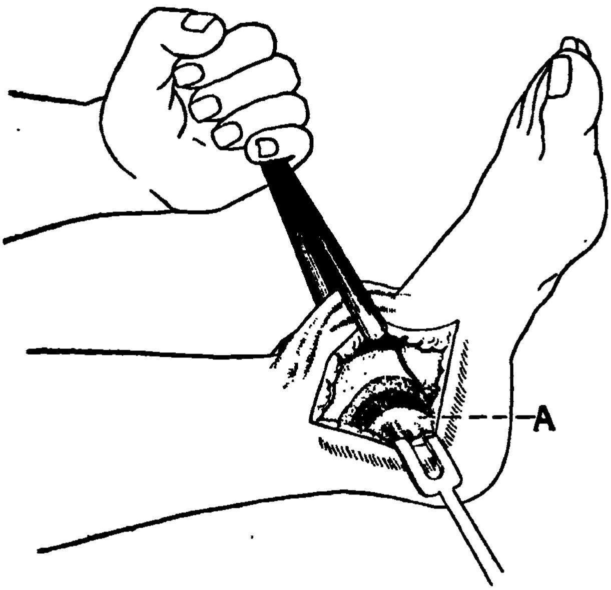


FIG. 11.—KÖNIG'S EXCISION OF ANKLE JOINT. A is the vertically divided malleolus.

König's Excision of Ankle.—König's excision of the ankle (Figs. 11, 12 and 13) gives admirable access to all parts of the joint. The internal incision begins on the anterior margin of the tibia, 2 in. above the ankle joint, immediately internal to the extensor tendons, runs downward and forward over the ankle joint, over the inner side and neck of the astragalus to end in front of the prominence of the scaphoid. A similar incision is made along the anterior surface of the fibula, across the articulation, ending in the outer side of the cuboid at the level of the astragaloscaphoid joint. Expose the capsule laterally and anteriorly in a similar way as in the preceding operation. Remove the anterior capsule and with it its covering synovial membrane. Vertically split the periosteum over each malleolus and introduce a broad-bladed chisel into this

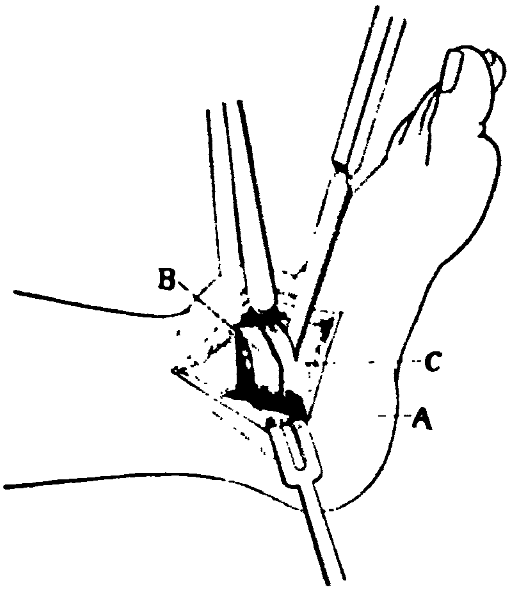


FIG. 12. KÖNIG'S EXCISION OF ANKLE JOINT. A is the vertically divided malleolus. Illustrates the division of the tibia and fibula (B) and the horizontal division of the upper surface of the astragalus (C).

incision and cut from each malleolus vertically a thin slice of bone (Figs. 11, 12 and 13, A). This is covered with periosteum, which is continuous above with the periosteum of the tibia and fibula and below with the lateral ligaments. Retract the shell of bone along with its attachments, divide the rest of the tibia and

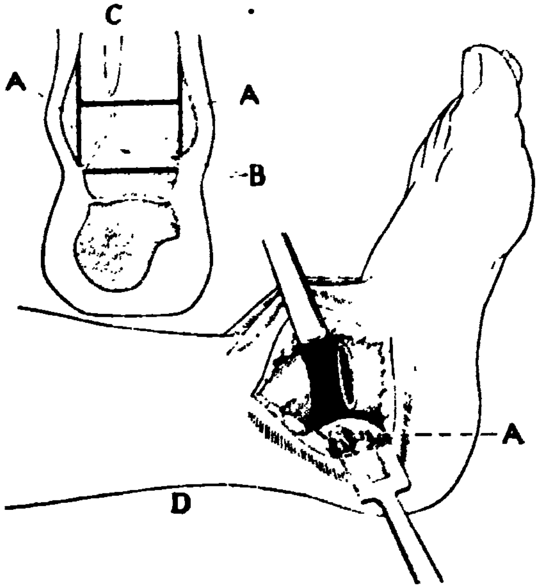


FIG. 13.—KÖNIG'S EXCISION OF ANKLE JOINT. D represents the result after removal of the bone sections. A is the malleolus. C gives the defect resulting from the removal of the bone. B is the astragalus. A the malleoli.

fibula transversely with the chisel, and remove the fragments. One had better, as a rule, remove the astragalus, if it be diseased, as in the preceding operation. If not diseased, its upper surface should be squared off horizontally by the chisel (Fig. 13 C, B being the astragalus). Remove all the synovial membrane and complete the operation as in the preceding procedure. Press inward or suture the lateral shells of bone to the tibia and fibula.

Ochsner's Excision of Ankle.—This procedure is described by Ochsner and Percy (12) as follows:

> "Any surgeon who has tried this mode of approach will always continue to employ it, as it insures a most satisfactory approach to the diseased tissues, and the results are likewise most satisfactory, both as regards the functional effects and permanency of cure. This is true even in cases that seem quite hopeless with any other method.
>
> "TECHNIC.—An incision is carried directly across the anterior surface of the ankle from malleolus to malleolus through the skin, superficial and deep fascia and the sheaths of all the tendons in the course of the wound. Externally the peroneal artery and nerve should be avoided, as well as the tendons of the peroneal muscles, which may readily be drawn out of the way. Internally the anterior tibial artery and nerve should be protected. Each tendon is then lifted up in the incision and transfixed with two fine catgut mattress sutures from 1 to 2 cm. apart. These sutures are caught in similar artery forceps for purposes of identification later, then the tendon is cut transversely between these sutures. After all the tendons have been disposed of in like manner, the joint is opened by a free transverse incision and the sole of the foot forced back upon the calf of the leg. In this manner the entire joint is opened freely, so that all diseased tissue may be removed. After this has been accomplished, as described above, the foot is placed in position, the ends of the tendons carefully adjusted so as to correspond exactly with each other. They are then sutured and the sutured areas are covered with fascia. Then the skin is stitched over all. If drainage seems necessary, it is applied through and through, and even in cases apparently requiring no drainage, it is usually well to pass a few strands of catgut or silkworm-gut entirely across the foot, permitting the ends to protrude from the lower angles of the wound so as to drain the serum, which may be secreted by the large surface during the first few days. A large dressing is applied and the foot immobilized in a position a little less than a right angle."

The result is very good after this operation. The free exposure of the surfaces insures thoroughness, and consequently the cure is usually permanent. The ankylosis of the surfaces immediately in the field of operation does not interfere with movement because the tarsometatarsal joints will supply the necessary motion. The tendons unite readily and act normally. Ochsner says that with this method it is often possible to obtain a useful foot in cases which formerly could only be relieved by an amputation.

Extracapsular Total Ankle Resection (Bardenheuer).—The incision is made through skin and tendons transversely across the tarsus and to this are added two lateral incisions above and below. The upper skin-tendinous flap is dissected up proximal to the sawn surface of the tibia, the lower flap downward. Behind the tibia and fibula two elevators are passed through and both bones are obliquely sawn through, taking more away in front than behind. The calcaneus is obliquely sawn through behind the lower end of the tibia and astragalus, which are held forward. Behind the tarsus, strongly held forward, the soft parts are separated toward the toes until one gets behind the tarsometatarsal joints, corresponding to the extent of the tuberculosis. The metatarsal bones are transversely sawn through and the sawn surface of the first metatarsal is nailed to that of the tibia and the sawn surface of the fifth to the fibula. The after-treatment consists in being sure that cicatrization takes place in the right-angled position. If that be the case, then a splinted shoe is worn.

Resectio Tibiocalcanea.—The skin incision extends from one malleolus to the other in an arch over the dorsum of the foot and is carried down to the bones. The flap is dissected back, the ankle joint opened, the astragalus removed, and the cartilage and upper surface of the calcaneus horizontally sawn off. The sawn surfaces are laid upon each other and nailed together from the heel. If necessary, the cuboid and scaphoid can be resected. This operation can be performed with transverse incision behind, which should only be used in case the soft parts behind the malleoli are involved in fungous growths, fistulæ, and skin ulcers. With the patient on the abdomen, the tips of the malleoli are joined by a downwardly convex curved incision, the Achilles tendon is divided, the akle joint widely opened, the astragalus is removed, the malleoli and the upper surface of the calcaneus horizontally sawn off. The rest of the operation is as above.

The indication for this operation is in cases in which the typical ankle joint resection is not sufficient for the thorough removal of the tuberculosis present.

Osteoplastic Ankle Resection (Wladimiroff-Mikulicz Fig. 14). The indications for osteoplastic resection (after Mikulicz) are:

1. Cases of foot caries, in which the disease is limited to the calcaneus, astragalus, and the ankle joint.
2. Extensive loss of substance in the region of the skin of the heel.
3. Injuries, particularly shooting injuries, with disturbance in the heel and its vicinity.
4. In addition, the operation has been frequently performed for malignant new growths of the heel, in pes equinovarus paralyticus and calcaneus. With deficiency in growth of the extremity, the increase in length produced by the operation is very welcome.

THE ORIGINAL MIKULICZ OPERATION (Fig. 14).—The first incision (Fig. 14, A1) is made from the tuberosity of the scaphoid transversely across the plantar surface until opposite the tuberosity of the fifth metatarsal. It is everywhere carried immediately down to bone. The second incision is drawn across the back circumference of the leg, a finger's breadth above the malleoli, and immediately divides the Achilles tendon. Th end points of these two incisions are joined by two lateral oblique incisions, which proceed from the malleoli to the lateral foot surfaces. The entire quadrilateral, circumscribed heel region is removed, while the dorsal skin bridge remains intact. The opening and exarticulation of the ankle joint now follow with dorsal flexion of the foot, the careful separation of the astragalus and calcaneus from the soft parts of the foot, and finally the removal through Chopart's joint. The malleoli are transversely sawn through above the joint surfaces of the tibia, likewise the bones in the peripheral section. The front half of the foot now hangs on the dorsal bridge (Fig. 14, B 2), which consists essentially of skin and extensor tendons, the resection of the ankle joint together with that of the astragalus, calcaneus and the posterior halves of the scaphoid and cuboid having been completed. The tibialis anticus and dorsalis pedis arteries must be preserved. After stopping the bleeding, the front portion of the foot, with its sawn surface in a pes equinus position, is placed against the sawed surface of the leg and fastened there with either wire or silk sutures, or the position is maintained by the plaster bandage (Fig. 14, C). In order that the toes may be dorsally flexed in a right-angled position, tenotomy of the flexor tendons is performed.

The patients walk, after healing, upon a kind of Pirogoff's shoe, upon the balls of the toes, which are bent forward and upward, as upon a living wooden foot.

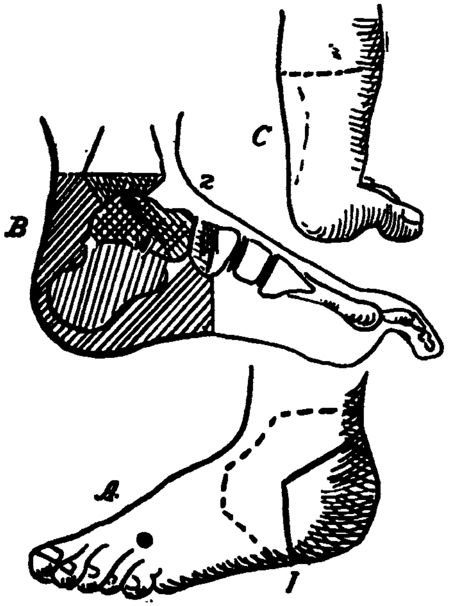


FIG. 14.—OSTEOPLASTIC ANKLE RESECTION (Wladimiroff-Mikulicz). A1 gives the skin incision. The shaded portion in B indicates the tissues removed. B2 is the anterior bridge of skin and tendons which remain. C is the ultimate result.

EXCISION OF THE SHOULDER JOINT

The following methods of excision of the shoulder joint may be employed:

A. Anterior straight incision through the front part of the deltoid (v. Langenbeck).

B. Anterior oblique incision (Ollier).

C. Osteoplastic exposure from above and behind (Kocher).

D. Extracapsular resection (Bardenheuer).

E. Temporary resection of outer third of clavicle (Catterina).

Anterior Straight Incision (v. Langenbeck).—With a pillow under the affected shoulder, the patient being on the edge of the table, the arm is abducted and rotated outward. The incision begins just external to and on a level with the tip of the coracoid process, is directed downward and outward along the outer side of the inner border of the deltoid, thus avoiding injury to the cephalic vein. It is about 4 in. long. The deltoid is bluntly separated and drawn to the outer side by retractors. With the arm rotated inward, the biceps groove with its contained tendon is identified. The joint capsule is incised vertically, parallel to and along the outer side of the biceps tendon, and this is carried downward on to the humerus, dividing the periosteum, to the point where it is intended to divide the bone. With a sharp periosteal elevator try to lift the periosteum from the bone toward the outer side and with it the tendons attached to the greater tuberosity. Try to do as much of the operation subperiosteally as feasible and avoid fraying out the periosteum as much as possible. Better yet, if the bone under the tuberosity is not diseased, chisel off the tendons, leaving a thin layer of bone attached to them. In this manner the periosteum, tendinous insertions, and fibrous capsule will be raised together and will remain attached. The periosteum will subsequently reproduce new bone. The periosteum is now attacked along the inner edge of the incision and is raised from the bone together with the biceps tendon and its sheath. If the biceps tendon is diseased, the sheath is opened and the tuberculous material is removed with curved scissors or a curette, while the tendon is held outside with the blunt hook. The periosteum is raised together with the subscapularis tendon from the internal or lesser tuberosity with the elevator, or a thin layer of bone with the attachment of the muscle is removed with the chisel. The head may then be divided in one of two ways: (1) In situ, with the soft parts protected from injury, a Gigli saw is passed about the bone or it is divided by a narrow-bladed saw; the head is then seized with bone forceps and removed. (2) The head is made to protrude through the wound by carrying the elbow backward and upward. It may be necessary to separate subperiosteally the posterior and lateral fibrous attachments from the bone. As much of the upper end of the humerus as is made necessary by disease is sawn off. Usually the line of section will pass through the tuberosities, any remaining disease in the tuberosities being thoroughly removed by the gouge or curette. The truncated end of the shaft should be carefully rounded off with saw or cutting forceps. Endeavor not to injure the epiphyseal cartilage in children, which ossifies usually about the 20th year. The epiphyses comprise the head and tuberosities, and the lower border runs upward and outward along the lower and inner half of the anatomical neck and then transversely under or through the tuberosities to the outer edge, where it lies above part of the insertion of the teres minor. Remove all the diseased matter from the glenoid cavity with a sharp spoon, chisel, or rongeur forceps. Dissect away all diseased synovial membrane, as well as the walls of all sinuses, with forceps and scissors.

With this subperiosteal resection, where it is possible, the rotators are lifted intact, which will permit subsequent rotation of the arm, whereas after the old operation, in which the rotators were completely cut across and the bone sawed on a level with the surgical neck, the resulting limb was often quite useless, rotation being always imperfect and sometimes entirely absent. To prevent subsequent stiffness, particularly with the subperiosteal resection, a layer of fascia with its pedicle on the upper arm should be placed, in suitable cases, over the divided surface of the humerus and sutured to the periosteum. A drainage tube should be placed in the lower angle of the wound. Posterior drainage should be provided for by passing a blunt dressing forceps through the incision and making it project on the posterior aspect of the joint. The point of projection behind is cut down upon, and the forceps, being passed through, grasp a drainage tube, which is drawn into the joint. The front wound is sewn about the drainage tube.

After a dressing has been applied a large pad of gauze is placed in the axilla to prevent the upper end of the humerus from being displaced from its contact with the glenoid cavity and sinking down and coming to lie under the glenoid. A figure-of-eight plaster-of-Paris dressing, comprising arm, diseased shoulder, and thorax, is applied, while the hand and forearm are suspended in a triangular sling.

AFTER-TREATMENT.—Windows are cut in the plaster splint and dressings are made as often as the discharge warrants. The axillary pad is of the greatest importance and should be worn for six weeks. The date of the beginning of passive motions of the joint will depend on the type of resection. If it is for old tuberculous disease where muscles have been divided and much bone removed, passive motions should not be begun until late, sometimes in the fifth week, since there is danger of causing a flail joint. When the parts surrounding are very little diseased, only a small amount of bone having been removed, and when the operation has been carried out subperiosteally, motions should be begun much earlier, sometimes between the second and third weeks. Abduction should be very gently made in the beginning to avoid dislocating the head. Massage, electricity, and passive motions should be carried out daily.

Osteoplastic Resection of Shoulder from Above and Behind (Kocher).—This method was particularly devised for cases in which the glenoid cavity is much diseased or the arthritis is very diffuse. In such cases the anterior route does not give sufficiently free access to the joint. Kocher's method gives excellent access to the back part of the joint, stress being laid upon the preservation of the deltoid (circumflex nerve). The patient lies upon the healthy side. The sharply arched skin incision extends above from the region of the acromioclavicular articulation, into which it soon enters, to the height of the shoulder, then along the upper edge of the crest of the spine to its middle point. It then curves laterally downward to a point two fingers' breadth from the posterior axillary fold. The tendinous muscular insertion of the trapezius is separated from the upper free edge of the spine of the scapula to the extent of the upper leg of the angular incision. Corresponding to the lower leg, the dense fascial leaf is split upon the posterior surface of the deltoid, and the lower edge of this muscle is then bluntly dissected free. The deltoid can now be easily lifted up and freed from the infraspinatus and teres minor, which, according to Kocher, is best accomplished by means of the thumb pushed beneath the muscle to the lateral edge of the spine. The most posterior fibers of the deltoid, held thus stretched out, are divided near their origin. In order now to be able to undertake the osteoplastic portion of the operation the finger is inserted along the upper edge of the infraspinatus and the lower edge of the supraspinatus, separating each muscle so far from the two surfaces of the spine that the external edge of the spine can be palpated both from above and below. The exposed place upon the spine is chiseled through in the direction of the neck of the scapula. One should avoid the body of the scapula for fear of injuring the suprascapular nerve. Prior to the chiseling it is advisable first to drill holes in the bones for the subsequent sutures. Kocher advises, instead of chiseling the end of the spine, the subcortical separation of the deltoid origin, with subsequent suture. The acromion is now free and, together with the entire deltoid muscle, is reflected as a cap, forward over the humeral head by means of both thumbs. The three posterior muscles, supra- and infraspinatus and teres minor, their tendinous portions covering the joint, now lie exposed. The upper edge of the supraspinatus is the guide to the point where the joint capsule is to be opened. The humerus is pushed upward and rotated outward, when the posterior prominence of the bicipital sulcus is visible on a line with the continuance outward of the upper supraspinatus edge. The capsule is incised along the direction of the biceps, and the tendon is exposed up to its origin in the glenoid process. The outward rotators are then subperiosteally separated, upon which the humeral head becomes visible as well as the glenoid cavity and the remainder of the joint structures. By flexing the elbow, rotating the shoulder, and pushing the head through the wound, it is now possible to inspect the whole joint and to judge whether it is necessary to resect the joint or merely to perform an arthrotomy. Complete the resection, removing all diseased tissues. Replace the deltoid flap and fix it in position by sutures. Provide for drainage. This operation appears formidable, but innervation is well preserved and the after-results are remarkably good. If partial resection is sufficient, Kocher's method permits the anterior part of the capsule, the subscapular muscle, and the coracohumeral ligament to remain uninjured, thus avoiding subsequent dislocation.

AFTER-TREATMENT. —Müller remarks that for the majority of the cases the arm should be bandaged in a right-angled abduction position and the well-known disposition of the head to become displaced behind the coracoid should be overcome by a triangle placed in the axilla and the upper arm should be directed forward. It is the same whether ankylosis is expected or a movable nearthrosis: the position in right-angled abduction must be maintained for the first few weeks.

For the prevention of ankylosis in suitable cases it is advisable to interpose between humerus and scapula a pedicled deltoid flap, in the anterior operation taken from the anterior part of the deltoid, in the Kocher procedure from the posterior portion. Wherever possible, the pedicle should be below.

Extracapsular Method of Shoulder Resection (Bardenheuer).—This method has two principal objects:

1. The radical removal of the bony and soft joint structures wherever possible without opening the joint.

2. The final attainment of an ankylosis with the arm in an elevated position.

In order to accomplish these more comfortably, Bardenheuer has again availed himself of the old flap method, which has the great advantage of giving greater oversight of the whole joint. The position is the same as that in v. Langenbeck's method. The skin incision is oval with convexity downward embracing the entire deltoid below. Through a small incision on the dorsum of the acromion this process is chiseled off at its insertion in the spine of the scapula. The skin and the deltoid are seized with the left hand and the latter's insertion into the humerus is divided with the knife. Blunt separation of the deltoid from its underlying tissues and blunt, extracapsular exposure of the joint follow; then strong (perpendicular) elevation of the abducted arm and blunt exposure of the neck of the scapula, and chiseling off of the same as well as of the coracoid process from front to back. The sawn surface is seized with iron-toothed forceps and is drawn outward, followed by separation of the soft parts from the internal part of the capsule; and then by circumscribing and sawing through directly under the head in the neighborhood of the tubercles, with avoidance of injury to the circumflex vessels and musculospiral nerve, the unopened joint is removed and the sawn surface of the humerus is nailed to the base of the freshened coracoid process with the arm in strong vertical abduction position. The wound is then sutured with projection outward of the nail, which is withdrawn in 10 days.

Results of Shoulder Resections.—These excisions offer to-day no particular danger. With all the methods mentioned a functionally good result is obtained, i. e. a movable nearthrosis, but on the whole the same good success is not obtained as in other large joints. The reason for this is to be sought in three conditions: 1. The changes in the muscles, which occur so frequently before the operation, particularly in the deltoid (severe atrophies, cicatricial degenerations, fistulous formations) injure the local functional result. 2. The result likewise depends on the extent of the disease. The less of the humeral head must be removed, the greater are the chances for an actively movable nearthrosis. With the removal of the entire humeral head the upper arm is too short for extensive movement of the arm to be hoped for. It is well to consider in such a case making up the defect caused by the loss of the upper humeral end by other bones (Lexer's joint transplantation), or the possibility of a transplantation of the scapulohumeral attachments, such as the deltoid and supraspinatus, lower down on the humerus. 3. The question of the after-treatment has a very essential influence upon the result of the operation.

From these grounds we may then sum up the essentials as follows: The technic of the operation should most positively maintain the function of the deltoid in order to attain an actively movable nearthrosis. The position in which the upper arm is to be maintained is at least a right-angled abduction. For the prevention of fibrous or bony ankylosis the interposition of a pediculated deltoid, pectoral (Payr) or fatty fascial flap should be considered. Where the deltoid exhibits severe fibrous changes, which will make functional restoration of the muscle impossible, then the formation of an intentional ankylosis appears justifiable. In cases of old severe tuberculosis it is in the interest of thoroughness to resect extensively, in extreme cases to make use of Bardenheuer's extracapsular method. In children and growing individuals one must bear in mind the influence of the upper epiphyseal line on the growth in length, in which it plays the chief rôle. In children the capsular attachment in the axilla reaches further distally than toward the acromion, although Bardenheuer uses his radical method in children, obtaining a shortening of 6 cm., which he considers does not seriously injure the function of the extremity; at the same time one must hold against this opinion the numerous functionally good results and healing of the disease after less radical resections. Only exceptionally is the radical operation of Bardenheuer indicated, but his after-treatment of elevated position of the arm is an undeniable advance. The tendency, often resulting, of the upper extremity of the humerus to dislocate downward and inward into the axilla is most surely overcome either through extension during the first 14 days or through the interposition of a suture, which is passed through the upper end of the humerus and the glenoid or acromion. Mention has already been made of a triangular plaster bandage which holds the arm in a slightly forward position, as well as of an axillary cushion.

The subperiosteal resection must be considered as the normal operation. Tumors of the upper humeral end must be regarded as an exception. In the early stages of such cases the division of the rotators, as in an exarticulation, is to be preferred. In these last cases an osteoplasty has begun lately to play a rôle and the defect is made up either preferably by an autoplastic transplantation, e. g., transplantation of the upper portion of the fibula with the head, or by a bone from a cadaver (Lexer, Küttner). There are instances in which attachment of muscles to the transplant has resulted in indifferent function; still reports are too few as yet to form a definite opinion as to this.

EXCISION OF ELBOW

Excision of the elbow may be performed according to the following methods:

A. Posterior vertical median incision (v. Langenbeck, Fig. 15, A).
B. Two lateral incisions (Fig. 15, A and B).
C. Ulnar straight internal incision (Fig. 16, A).
D. Kocher's incision.
E. Ollier's bayonet incision (Fig. 16, B).
F. Extracapsular resection—Bardenheuer's operation.
G. Atypical resections.

Excision by Posterior Median Incision (v. Langenbeck's Operation, Fig. 15, A). —The patient is supine on the table near the edge. The affected extremity is flexed to a right angle at the elbow and the forearm lies on the chest of the patient. This makes prominent the bony outlines of the elbow. A vertical incision is made over the middle of the olecranon, 2 inches of it being above the tip of the olecranon and 2 inches below. The triceps is split and separated and the knife opens the posterior capsule; the incision is continued upward on the humerus and downward on the ulna, splitting the periosteum. With a sharp periosteal elevator the inner aspect of the wound is first freed and the inner half of the triceps with the periosteum is lifted up from the olecranon, closely hugging the bones to avoid injury to the ulnar nerve, which should not be seen. The internal lateral ligament, the common origin of the flexor muscles, and the periosteum are all separated from the humerus and ulna. The outer half of the wound is next freed subperiosteally. The outer half of the triceps is lifted up from the olecranon—care being taken not to sever its expansion into the deep fascia of the forearm—together with the anconeus, which is a continuation of the anterior portion of the triceps. The external lateral ligament, the common origin of the extensor muscles, and the periosteum are all separated from the bone. The supinator brevis is freed from the external condyle and from the ulna and is turned forward, special care being taken not to injure the posterior interosseous nerve which runs between its superficial and deep parts. Following these procedures, the bones are entirely bare on their posterior and lateral aspects.

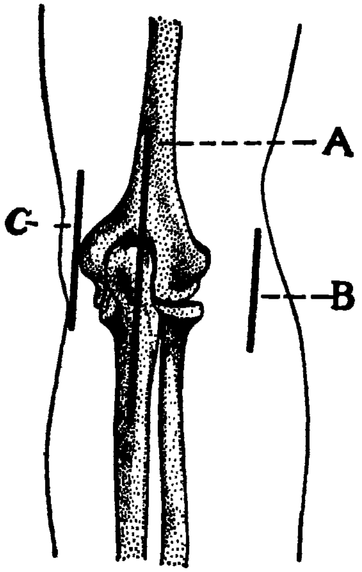


FIG. 15.—INCISIONS FOR RESECTION OF ELBOW JOINT. A, Langenbeck's posterior vertical median incision; B and C, incisions for resection by two lateral incisions.

By acutely flexing the forearm, by pressing backward on the lower part of the humerus from in front, and by traction on the forearm the humeral end may be made to protrude through the wound. It is then separated subperiosteally from the soft structures in front to the desired extent. The articular end of the humerus is seized with lion-jaw forceps and removed by means of the saw. The saw level will depend on the amount of disease present. Jacobson says the saw should pass above the level of the epicondyles and through the highest part of the epitrochlea. The radius and ulna are made to protrude and are sawn off without injury to the soft parts. The line of section of the ulna should remove the greater and lesser sigmoid cavities with the olecranon. The brachialis anticus should not be separated from its point of insertion. The line of section of the radius should be on a corresponding level, usually the line of section going just below the head. The insertion of the biceps should remain uninjured. All diseased synovial membrane is removed, including the extension between the radius and ulna. All foci of disease are gouged out of the bones and all sinuses are removed.

In young subjects under 17, whenever possible, the epiphyseal lines are to be avoided. In this connection it may be noted that the principal growth of the humerus in length occurs at the upper end. The line of the lower epiphysis of the humerus runs transversely and somewhat irregularly across the bone just above the tips of the condyles. The epiphyseal line of the ulna runs obliquely from in front downward and backward, beginning anteriorly about ¼ in. from the upper extremity of the olecranon. The epiphyseal line of the radius runs transversely about ¼ in. from its upper articular surface.

In patients operated upon early in the course of the disease, where one feels reasonably certain that all the disease has been removed, it is well to interpose a flap of fascia and fat between the sawed surfaces of the bones, or to interpose a flap taken from the anterior surface of the triceps. (For details see Arthroplasty.)

The arm and forearm are brought in proper relations with each other, the structures are sutured together with catgut stitches, drainage, if thought necessary, being provided for by a rubber tube, and the wound is dressed.

The after-treatment is most important. A jointed metal splint is very useful. This allows of a change in the angle of the joint at will. Pels-Leusden puts the arm up in full extension because he says that between the bone ends there is a sac of soft parts which must shrink considerably, if one is to expect the bones to come together afterward. He says that if one flexes the forearm to a right angle, the soft parts on the back remain stretched and cannot retract, resulting in a more or less flail joint. They remain in this position for 3 weeks after which gradual flexion exercises are instituted.

Most authorities recommend putting the elbow up partially flexed (135°) with the forearm midway between pronation and supination. Pronation and supination should be practiced daily from the start. After 14 days gentle flexion and extension, motions may be carried out daily.

Cheyne and Burghard (Vol. III) describe the after-treatment so well that I quote them verbatim.

> "Unless a large amount of bone has been removed, the splint may be left off after four weeks, the arm carried in a sling, and passive movement still more vigorously employed. This is the critical period in the case since about this time stiffness tends to increase rapidly, and therefore active motions should be encouraged. There is seldom any difficulty in preserving pronation and supination. Two conditions must be carefully guarded against: on the one hand, the limb must not be allowed to get stiff; on the other, a flail joint must be avoided. It is not until about a month has elapsed after the operation that the surgeon is able to judge what is likely to happen. When the case is going on well there will be some slight difficulty in obtaining complete flexion and extension, although movement should be fairly good; if, on the other hand, the joint be quite loose and complete extension can be got without difficulty, a flail joint is to be feared, and it is then best to put the arm up in plaster-of-Paris for three or four weeks without any further passive movements. It will then be seen whether

the joint is still loose or whether sufficient contraction has occurred to require passive movement. If the joint be then too lax, it is well to apply a hinged metal apparatus to strengthen the weakened movement and to prevent lateral mobility, and, if worn for some months, it is quite possible that a joint which was at first very lax may finally become satisfactory."

The Ulnar Internal Straight Incision.—This operation is intended for procedures in the neighborhood of the epicondyle and internal condyle of the humerus (fractures, bony infectious foci). For the total resection of the elbow joint it is not suitable, since the dislocation out through the wound of the bared bony ends internally (cubitus valgus), on account of the ulnar nerve, is difficult. The procedure is more readily accomplished from the radial side. The forearm is flexed (145°) at the elbow joint, abducted, and outwardly rotated in the shoulder joint. The operator stands or sits between the thorax and arm. From in front of the internal epicondyle proximally one palpates the internal intermuscular septum as a ridge, and behind it the round cord of the ulnar nerve, which runs behind the epicondyle. The skin incision is made directly upon the intermuscular septum, just in front of the epicondyle. From here it runs parallel to the posterior ulnar border downward about 3 cm. The entire incision, about 6 to 8 cm. long with the forearm flexed, is curved. The fascia and the intermuscular septum are split until the front surface of the internal epicondyle is reached. With a bone scalpel held close to the bone, the tendinous origin of the pronator teres, flexor carpi ulnaris, palmaris longus, flexor digit sublimis, and the front part of the internal lateral ligament are divided and separated, while at the same time the internal portion of the capsule is divided upon the bone. By carefully prying off the soft parts on the front of the lower humeral, as well as on the internal border of the ulna, with greater flexion of the forearm, taking care to avoid injury to the visible ulnar nerve lying on the internal edge of the flexor carpi ulnaris, then the internal portions of the joint become visible. Now, by more strongly flexing the forearm radially, thus putting the back part of the internal lateral ligament on the stretch, the deeper parts of the joint can be inspected. Whatever is necessary is then done, and the parts sutured in their original anatomical positions.

Resection of the Elbow with Radial Lateral Incision (Kocher).—This is considered by many surgeons to be the best method of resecting the elbow.

The lateral incision begins upon the outer edge of the humerus, 3 to 5 cm. above the external epicondyle, and runs vertically downward over the head of the radius. It then continues downward along the anterior border of the anconeus 2 in. below the tip of the olecranon, where it curves backward over the ridge of the ulna. The incision has the advantage, as Kocher has maintained, of separating the muscles supplied by the branches, curving off in the arm, of the musculospiral nerve (supinator longus, extensor carpi radialis longior in front, and the triceps and anconeus behind) from those which are supplied by the deep branch (posterior interosseous) of the musculospiral nerve (extensor carpi radialis brevior and extensor carpi ulnaris). The lowermost fibers of the anconeus are divided sharply upon the ulna.

At the upper end of the incision penetrate to the outer edge of the humerus by separating the supinator longus and the extensor carpi radialis longior in front from the triceps behind. Further downward, along the external condyle, penetrate between the extensor muscles in front and the anconeus behind, until the ulna is reached. The next proceeding is the laying bare of the joint ends. A long triceps-anconeus flap, with fully extended forearm, is fashioned subperiosteally from the upper part of the ulna with the elevator, from the olecranon with a strong knife, and again in the lower arm the tissues are pried from the humerus with the elevator. This flap is reflected over the olecranon as a cap toward the ulna side. If the olecranon is certainly healthy, this proceeding is rendered easier by chiseling off from the back part of the olecranon a slice of bone which remains attached to the triceps (König, Kocher), forearm fascia, and anconeus. The front soft parts, after subperiosteal or subcortical separation of the capsule, extensor tendons and external lateral ligament from the humerus, are drawn forward. The now movable joint ends are separated by a powerful ulnar flexion and can be luxated. This will be rendered easier by separating the extensors from the lower humeral end by chiseling off the external epicondyle. In many conditions the dislocation will not be necessary. In the typical resection, just as in Langenbeck's resection, the soft parts must be carefully separated from the internal epicondyle together with the internal lateral ligament. This can be accomplished subperiosteally or subcortically by chiseling off the epicondyle. The remainder of the operation is as in the Langenbeck procedure.

Extracapsular Resection of the Elbow (Bardenheuer).—Reflect a horseshoe-shaped flap of skin, with its base below, and of the width and at the position of the epicondylar line. This flap is reflected downward. A second flap, with convexity below, is now fashioned out of the triceps tendon, the periosteum of the ulna, and the origins of the anconeus and supinator longus. After division of the olecranon tip, this flap is carefully pushed off, by means of a tampon, from the posterior capsular pouch and from both sides of the triceps tendon (bursa sub tricipite), and is reflexed upward. The already mentioned bursa (the upper back joint capsular pouch) is then by means of tampons pushed downward from the back surface of the posterior supratrochlear fossa. Both epicondyles are then circumscribed toward the front and the origins of the flexors of the hand and fingers are separated from the internal epicondyle and, further down, from the ulna. Externally the extensors and the anconeus are separated from the external epicondyle and condyle. The ulnar and musculospiral nerves should previously have been isolated and drawn to one side. The biceps and brachialis anticus should be raised up from the front surface of the joint capsule and forearm. The joint ends in association with the joint capsule are thus isolated. The humerus is sawn through from behind forward just above the separated capsular pouch. A sharp hook seizes the lower sawn surface and drags it down and back, thus exposing the anterior surface of the joint. The musculospiral nerve at its point of division is then securely protected from injury, the brachialis and biceps are bluntly raised up from the joint, and the neck of the radius on an elevator is transversely sawn through at a lower level than the point at which the ulna is divided. This is important for the preservation of pronation and supination. As the last act the ulna is chiseled from the olecranon obliquely from above and behind, forward and downward. The surface resulting from the chiseling should be extracapsular. The articular ends of the bones plus the whole joint cavity can now be removed in one piece. In order to produce fixation, with forceps, saw, or chisel, excise a wedge-shaped piece of bone from the humerus end. Trim the upper end of the ulna so as to make it fit into the notch in the humerus while the forearm is held in a position of a little less than a right angle to the upper arm. Unite the ulna to the humerus by means of a nail. This nail projects through the plaster bandage and should be removed on the eighth day. Finally the resected end of the radius is covered over by a fascial and muscular flap taken from the supinator longus muscle, in order to prevent ankylosis and to maintain pronation and supination. The muscles and fascia are then united over the cavity without drainage. After the eighth day gymnastic exercises are begun.

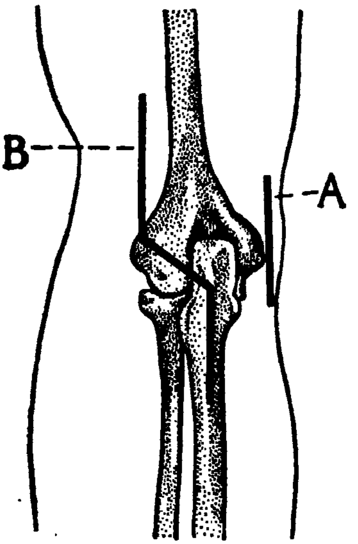


FIG. 16.—INCISIONS FOR RESECTION OF ELBOW JOINT. A, incision for resection by the ulnar straight internal incision. B, Ollier's bayonet incision.

Atypical Resection of the Elbow.—The incision is the posterior longitudinal one already described. The base of the olecranon is cleared of its coverings and divided transversely, either from without inward with a chisel, or from within outward with a Gigli saw. The olecranon is reflected upward with the attached triceps tendon. Examine the olecranon carefully, as it is the most common site of osseous foci of disease in tuberculosis of the elbow. With chisel or sharp spoon remove diseased bone wherever found. With forceps and knife or scissors excise diseased soft structures. Thoroughly cleanse the joint cavity. Reunite the olecranon to the ulna with bone pegs, steel nails (the ends protruding through the wounds), silver wire, or chromicized catgut. Close the wound and dress.

Results of Elbow Resections.—A not too late resection of the elbow furnishes better results than if one adheres to the principle of choosing a resection as a last resort. Positively diagnosticated (Röntgen pictures) intra-articular disease with eruption into the joint justifies an earlier resection than in many other joints which furnishes the best means for a cure. Well-retained function of the muscles is a very essential factor in producing a good result. A movable nearthrosis is often better attained after total resections than after irregular (step-like) removal of the bony ends. The results depend less upon the schematic use of a particular method than upon the personal experience of the operator and the individualizing indications of the operation and, not the least, upon a thorough after-treatment.

An inevitable result of elbow resections was a flail joint, which, before the introduction of the subperiosteal method, occurred much more frequently than it does to-day. It is a result of extensive removal of the joint ends, but can occur also as a result of necrosis of the periosteum, great change in the musculature, and improper after-treatment. So far as the first factor is concerned, long fixation of the resected surfaces in contact must be maintained. Eventually nailing may be required. An ankylosis is best prevented by early and frequent changes in position and early active and passive motions. Another help in preventing ankylosis is the interposition of a pedunculated fascial and muscle flap, which is best taken out of the triceps, the pedicle being proximal. If aseptic relations obtain, the fixation of the forearm to the humerus can be maintained by two strong, not too tightly tied, silk bone sutures, one external and one internal, which at the same time act as artificial lateral ligaments and excite the formation of connective tissue. The tendency to lateral subluxation of the resected surfaces is also prevented without injuring the physiological movability.

The recurrence of tuberculosis in an already resected joint will cause one to consider the possibility of opening up the joint again and by means of an arthrectomy, or in some cases of a new resection, arriving at a good result.

EXCISION OF WRIST JOINT

A. Typical subperiosteal resection (Ollier's Operation) by radial and ulnar dorsal incisions (Fig. 17, M, M', and N).

B. Resection of wrist joint with dorso-ulnar incision (Kocher's Operation).

A. Resection of the Wrist Joint by Radial and Ulnar Dorsal Incisions.—Beginning opposite the center of the dorsal surface of the second metacarpal bone, an incision is made which runs obliquely upward and inward, following the outer border of the extensor indicis tendon. This incision (Fig. 17, M and M') is carried upward until it reaches the center of a line joining the two styloid processes, where it changes its direction slightly to that of the line of the forearm, i. e. vertically. The internal branch of the dorsal division of the radial nerve is avoided, if possible. The extensor indicis tendon is retracted outward without opening its sheath. The tendon of the extensor carpi radialis brevior is followed down to its insertion into the base of the third metacarpal bone and is drawn outward but is not cut. The periosteum of the head of the third metacarpal is incised upon the inner side of the insertion of the extensor carpi radialis brevior. This incision is carried upward through the periosteum of the metacarpal, carpal and radial bones, capsule of the joint and the posterior annular ligament between the extensor indicis and extensor longus pollicis. The ulnar incision is next made (Fig. 17, N). It runs along the back of the ulna to the inner side of the extensor carpi ulnaris, 1¼ in. above the point of the ulnar styloid process to a point ¾ in. above the base of the fifth metacarpal bone, avoiding, if possible, the dorsal cutaneous branch of the ulnar nerve. It passes through the posterior annular ligament, joint capsule and periosteum of ulnar, carpal, and metacarpal bones. The periosteum and ligaments are raised up from the dorsal surface of the carpal bones as far as can be done through the radial incision. All the tendons are raised with their periosteum entirely from their grooves with their sheaths unopened. The same procedures are carried out through the ulnar incision, hugging the bones closely, and elevating all the soft structures from them. As each carpal bone is separated, it is seized from the dorsum with bone forceps and twisted from side to side. Its lateral attachments as well as its palmar attachments are divided close to the bone. All the carpal bones are removed excepting, if possible, the pisiform bone, the unciform process of the unciform bone (which should be cut through with bone pliers), and the trapezium. All of these have numerous and important tendons inserted into them. The trapezium is rarely diseased, and it forms an important part of the thumb joint. The lower ends of the radius and ulna are now freed from periosteum, protruded through the wound, and

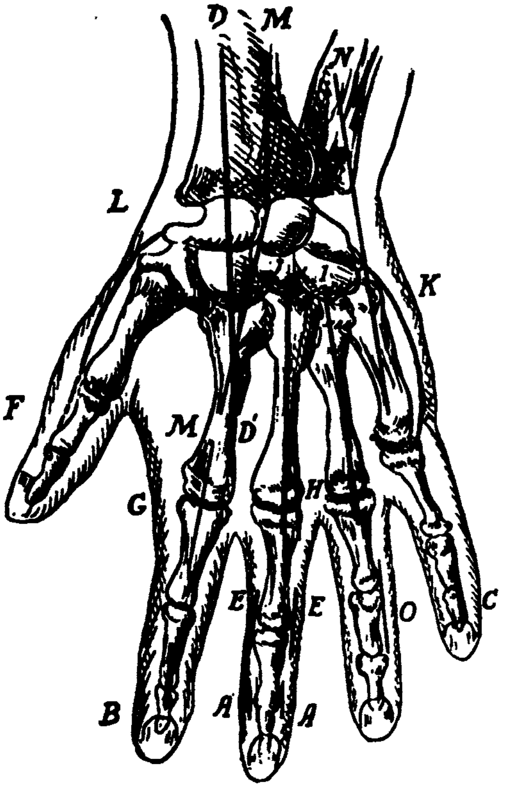


Fig. 17.—Incisions for Resections of Wrist and Finger Joints. M, M, and N, Ollier's method by radial and ulnar dorsal incisions. D and D', Langenbeck's operation by dorsoradial incision. A, A, excision of second interphalangeal joint by two lateral incisions. B, of second interphalangeal joint of index, by dorso-external incision. C, of second interphalangeal joint of little finger, by dorso-internal incision. O, of second phalanx of finger by dorsolateral incision. E, E', of first interphalangeal joint, by two lateral incisions. F, of first phalanx of thumb, by dorso-external incision. G, of metacarpophalangeal joint, by dorso-external incision. H, of metacarpophalangeal joint, by dorso-internal incision. I, of metacarpal, by dorsal incision. J, of metacarpal, by dorsal incision, with added angular incision. K, of metacarpal of little finger, by dorso-internal incision. L, of metacarpal of thumb, by dorso-external incision.

removed just above the articular cartilages, or, if but little diseased, they may be simply gouged in situ without being extensively freed. The articular ends of the metacarpals should be gouged, if not much diseased, or, if extensively involved, removed by being protruded into the wound, and a thin slice of bone taken off with a narrow saw. Remove all diseased soft parts. Suture the divided annular ligament. Insert a rubber tube drain. Suture and drain. The cavity may be filled with bismuth paste prior to closing it. The forearm should be placed on a splint in dorsal flexion, leaving the fingers and thumb free. A plaster-of-Paris splint is probably the best and easiest to apply. It is moulded on the anterior aspect only, being 3 in. wide with the hand dorsally (posteriorly) flexed. This position is maintained because it is the natural position of the hand in powerful closing of the fingers. The fingers should be most carefully exercised from the first to prevent fibrous union of the tendons. The limb must be immobilized until the wrist has solidified considerably. This may take 6 months or longer. The muscles of the forearm should be massaged and applications of electricity made every day. In order to shorten the convalescence, Tietz has advised and carried out division of the tendons, overlaying them on each other and sewing them in this position. Bardenheuer nails the metacarpals to the radius, endeavoring to get an ankylosis from the start. In case the radius and not the ulna be diseased, then in addition a corresponding piece from the ulna must be removed. In case, however, the ulna alone be diseased, and the radius healthy or healed, the ulna alone should be removed, leaving the healthy radius intact.

B. Resection of Wrist Joint with Dorso-ulnar Incision (Kocher).—The hand is prone, with slight radial flexion. The skin incision begins over the middle of the fifth metacarpal and runs upward, slightly curving inward over the middle of the wrist joint and forearm for from 7 to 9 cm. The dorsal branch of the ulnar nerve is to be avoided. The tendon sheaths of the extensor minimi digiti and extensor communis digitorum are split lengthwise, and the tendons retracted to the radial side. The joint capsule is now exposed and is split in the direction of the skin incision from the base of the fifth metacarpal up to the ulna. Separation of the tendon of the extensor carpi ulnaris from its depression on the dorsum of the ulna follows, and in connection with it the capsule on the ulnar surface is subperiosteally separated; likewise the capsule on the radial side of the ulna. If the intra-articular fibrocartilage be diseased, it is excised. The capsule is separated from the cuneiform bone, in which procedure the joint between this bone and the pisiform is opened. This last bone remains connected with the tendon of the flexor carpi ulnaris. The separation of the soft parts from the ulna and carpus is now continued further on the ulna and volar side partly with knife, elevator, or Cooper's scissors. The unciform process of the unciform bone is best retained, in order to protect the deep branch of the ulnar nerve, which winds around it. The bundle of the flexor tendons is lifted all together out of its depression, following which the capsule, strengthened by the volar ligaments, is successively separated from the bases of the V, IV, and III metacarpals. The insertion of the flexor carpi radialis into the base of the second metacarpal is retained. The stronger capsular section is then separated from the volar side of the radius after lifting up the soft parts. Finally the baring of the lower radial end is performed upon the dorsal side after lifting up and radially retracting the extensor tendons and their sheath. The extensor carpi radialis longior and brevior are also taken out of their depression on the radius, where possible, with retention of their insertion into the dorsum of the second and third metacarpals. Now the entire carpus is dislocated on the forearm by a powerful volar and radial flexion—this latter carried so far that the radial surface of the thumb touches the forearm. One can easily, if it be necessary, lay bare the radius end still further by separating the insertion of the supinator longus. Then follows the extirpation of the carpal bones, as described in the various methods, wherever possible, leaving the trapezium and pisiform. Kocher recognizes difficulties in his method only in extirpating the three radial metacarpal bases, and in diseases of these considers the dorsoradial incision better. He recommends in general the curved sawing off of the joint ends—metacarpals convex, forearm bones concave. An advantage of his method Kocher claims to be the retention of the two extensors carpi radialis and the good oversight into all recesses of the wrist and carpal joints. The separation of the tendon of the extensor carpi ulnaris he considers is without consequence since even without it there is a tendency to ulnar flexion of the hand, so that even the entire abolition of the function of this muscle is rather advantageous than otherwise. One can besides give to the tendon, which should be shortened, a new insertion into the fifth metacarpal. Kocher also insists on the necessity of fixing the hand in dorsal flexion during the after-treatment, to give the necessary stretching to the flexors.

Results of Wrist and Carpal Resections.—If tuberculosis be the indication and if there are present profusely secreting fistulæ, then the frequent mixed infection will probably lead to a poor result. If to-day the result and the worth of resections of the wrist are judged in general to be unfavorable, this is due to the very different indications. Wrist resections have only lately and slowly taken a place in surgery. With an improved technic and with a thorough after-treatment as well as a more extensive operation, there have been a number of good results. A too long delayed resection renders doubtful the end result both as regards cure of the disease (tuberculosis) and as regards subsequent function. Many agree that the modern operative technic of wrist resections, particularly in combination with applications of iodoform and physical methods of cure (residence near the sea, Röntgen-ray applications, exposure to the sun's rays), produce satisfactory and good results in the majority of cases. If the wrist joint fungus has broken through into the tendon sheaths, or if fistulæ have existed for a long time, then the outlook for a resection, even the most radical, is very moderate. In spite of this, if after the operation the tuberculosis heals and if only the thumb retains a moderate, active motion, then the [illegible]al result is indeed much better than the best amputation stump of the forearm. Partial carpectomies may be performed in some fresh cases after assured localization, powdering the defect with iodoform or filling it with the iodoform plug, and finally closing completely the soft parts. After postoperative recurrence of the disease, in case there be no complicating severe tuberculosis of other organs, satisfactory results can be obtained often by means of secondary resections. Forearm amputations should be employed in such cases only as a last resort. On the average, one can count on 50 per cent. of cures with partly good and partly satisfactory hand and finger functions.

Excision of Finger Joints (Fig. 17)

Typical resections of the small joints of the fingers are unusual. Incomplete excisions for dead bone are more common. In suppurative processes and tuberculosis one occasionally removes parts of the cartilaginous joint surfaces as sparely as possible, always remembering the epiphyseal lines in growing patients, which must be respected and avoided. As important as the bones is the respecting of the tendons, that of the flexor sublimis being inserted into the lateral margins of the second phalanx, those of the flexor profundus into the bases of the last phalanx, while on the dorsal surface the tendons of the extensor communis are inserted into the bases of the second and the dorsal surface of the last phalanges. Excision of the interphalangeal joints is very satisfactory. Excision of the metacarpophalangeal joints often leaves a useless joint except in the case of the thumb, where it is satisfactory, especially if the phalangeal epiphysis be left, there being no lower metacarpal epiphysis. The subperiosteal method should be carried out if possible. The capsule and ligaments are stripped off and held to one side and the bone removed with gouge or Gigli saw. The ends of the bone should be smoothed off so that the proximal joint surface will be convex, the distal concave. Whenever possible one should interpose a flap of soft parts between the ends of the bones in order to prevent an ankylosis. One should remember that in the working classes a motionless stiff finger joint injures the usefulness of the entire hand more than the loss of a finger.

Incisions.—For resection of the second phalangeal joint use two dorsolateral incisions (Fig. 17, A, A).

For the first interphalangeal joint employ two dorsolateral incisions (Fig. 17, E, E).

For the metacarpophalangeal joint use a single lateral dorsal incision, pushing aside the dorsal extensor tendon (Fig. 17, H).

Arthrotomy and Resection of the Sternoclavicular Joint

The joint can be opened by an incision over its front in line with the axis of the clavicle. For simple drainage one should make the incision at the lower portion of the front, which is the weakest part of the joint, where the best drainage is also accomplished. For a very wide opening of the joint a half-moon-shaped incision is made with its convexity downward, running in the direction of the joint line.

Resection.—This operation is but seldom indicated, usually for tuberculosis. The extracapsular method of Bardenheuer, as with other joints with a short capsule, is to be particularly recommended. With the chisel a portion of the sternum is divided, and externally, just beyond the joint, the clavicle is likewise divided. The careful separation from side to side of the back of the capsule from the structures lying upon it is accomplished with more safety than if the separation is begun from above downward without divisions of the bones.

ANKYLOSIS OF JOINTS

Ankylosis of the joints may be classified as follows:

A. *True ankylosis*, in which the stiffness is in the joint tissues themselves.
   1. Complete or bony.
   2. Incomplete or fibrous.

B. *False ankylosis*, in which the stiffness is in the tissues outside the joint.
   1. Contraction and rigidity of the peri-articular tissues.
   2. Adhesions of muscles to the bones in the vicinity of the joint.
   3. Extra-articular, involving skin scars, tendons, fascia, nerves and arteries.

The duty first devolving on the surgeon in these cases is to ascertain exactly the nature of the ankylosis, whether the union is bony, or fibrous, or whether the obstruction to motion is due to distorted and deformed bond ends, to exostoses, or to intra-articular fractures. This decision is made by carefully examining the history, by good skiagrams and by careful examination of the joint under ether if necessary. If there be any motion present, then the union is not bony. No measures whatever should be employed to mobilize a joint that is the seat of active disease.

FIBROUS ANKYLOSIS

If fibrous ankylosis be due to recent tuberculosis and the joint be in a good attitude and painless, the wisest course is to let it alone, since encapsulated foci may lurk in the bone marrow and in the intra-articular adhesions for a long time, ready to light up afresh if motion be resumed. If a tuberculous joint be ankylosed by fibrous tissue in a faulty attitude, prolonged traction should be applied, with the patient in bed, until the deformity is overcome, after which a splint should be used for some time to hold the joint in its correct position. Or the reduction may be made at one sitting under ether, dividing the contracted tissues, if this be necessary, taking care not to use undue force. For the milder cases of fibrous ankylosis, following the other diseases, bakings, passive and active hyperemia, vibratory massage, ordinary massage, and active and passive motions will accomplish much. For the severer forms we may have to break up the adhesions under ether (taking care not to fracture the bones), and then put the joint up in plaster in an entirely different attitude for a couple of weeks, following this by the treatment as outlined for the milder forms. A repetition of the operation may be advisable several times, with a changed attitude each time.

For the most severe cases we may be compelled to consider the advisability of an arthroplasty in an adult.

Bony Ankylosis

When the joint is in good position the surgeon will have to decide for himself whether he shall advise an arthroplasty or not, judging by the results he himself has had with the operation. A stiff and painless joint is to be preferred to a painful movable one.

When the joint is stiff by bony ankylosis in a faulty position we have the choice of an osteotomy and correction, or of an arthroplasty.

Arthroplasty of Individual Joints

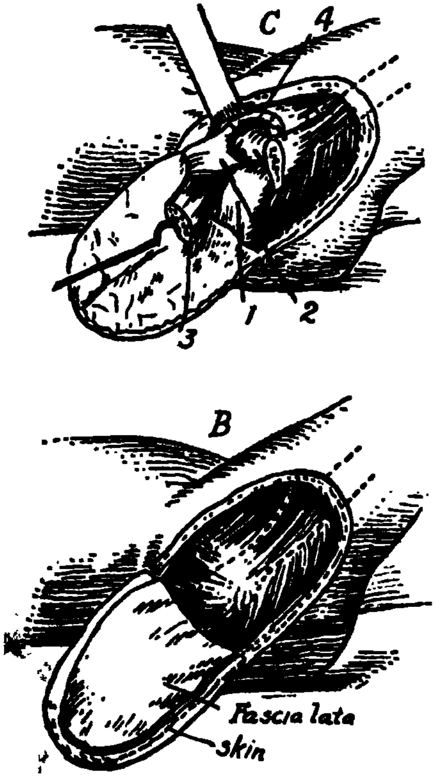
Many of these descriptions are taken from an article by Murphy (10a). Arthroplasty (or arthrolysis) is the bloody mobilizing of ankylosed joints.

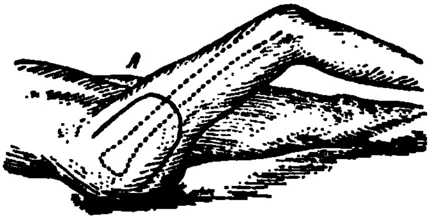
Arthroplasty of Hip. Two incisions have been used by Murphy. The first is an inverted U-shaped incision, 3 in. wide and 5 in. in length, with base downward, beginning 1½ in. above the trochanter and 1 in. behind it, and extending downward 2 in. below the trochanter, and then upward to a point opposite the commencement of the incision (Fig. 18, A). A flap, consisting of skin, superficial fat, and fascia lata (Fig. 18, B), is made and lifted up.

The second incision is made along the iliotrochanteric line. It commences at a point 1 in. below and outside the trochanter and extends upward for a distance of about 5 in. in a straight line with the anterior superior spine.

The next step in the operation is to free the trochanter from the shaft, leaving the muscles attached to it. A chain saw is passed around the base of the trochanter from before backward and the trochanter is sawed off downward and outward and is retracted upward out of the field of operation, carrying with it the attached muscles. The obturators and pyriformis are then divided and both ends transfixed with sutures for subsequent approximation. The joint is now freely exposed. The capsule of the joint is next incised at its attachment to the neck of the femur and it is pulled upward to the margin of the acetabulum without forcing it from its attachment to the latter. This enables it to be interposed later, if necessary, between the head of the bone and acetabulum, so as to assist in the formation of a new lining for the acetabular cavity.

The formation of a new femoral head is next in order. The first thing to be done is to separate the ankylosed head from the ilium as near the normal anatomical line as possible. This is accomplished by chiseling out the bony tissue filling the acetabular cavity by means of an ordinary carpenter's or cabinetmaker's curved chisel, about 1½ in. in width. The chisel is driven in obliquely toward the acetabular cavity for the depth of 1 in. all the way around the head, as near the normal conformation as possible. When the chiseling process is complete, with the chisel as a lever and the thigh held by an assistant, the head is then fractured out of the acetabulum. The acetabular cavity is then fashioned with a special globular reamer, so as to receive the new femoral head, which will be fashioned similarly from the bony mass chiseled out of the acetabulum.





18.—Arthroplasty of Hip. A is the incision; B shows the flap, lifted up, consisting of skin and fascia lata; C shows the operation almost completed; 3 is the divided trochanter with its attached muscles brought through the split fascia lata, 1, 2, which is passed posteriorly between the femoral head and the acetabulum and brought out anteriorly, 4, where it is sutured.

The main reliance for obviating the recurrence of the ankylosis is placed on the flap of the deflected fascia lata, which is made by splitting the original V-shaped flap. The fascia lata and a layer of subcutaneous fat are dissected free from the skin, the base being upward. Grasping the edge of the flap of fascia lata with tissue forceps, it is drawn into the joint, passed over the femoral head, and sutured to the posterior margin of the acetabulum. Or it is passed behind the head and drawn anteriorly, where it is sutured to the acetabular margin or to the capsule at its attachment to the acetabulum. The base of the fascia lata flap (Fig. 18, C, 1 and 2) may have to be split to allow the sawed-off great trochanter with its attached muscles (3) to be drawn through it. The ends of the obturator and pyriformis muscles are reunited. The trochanter is brought down, fitted to its original position, and securely fastened with a wire nail, six or eight penny. The nail is driven into the bone along the axis of the neck. The wound is closed. No drainage is used. The patient is then placed in a Rainey travois splint (both legs abducted), and a Buck's extension is applied so as to prevent pressure necrosis of the interposed flap.

The patient is kept in bed in the dorsal position for from 7 to 10 days, when passive motion is instituted. This consists in first raising and lowering the leg and attempting to flex the leg on the thigh, and the thigh on the abdomen. This is done every day, and at the beginning of the second or third week lateral motions are begun consisting in forcible abduction and adduction. The splint is kept on for 3 or 4 weeks. The patient is then allowed to be up and around on crutches and is encouraged to swing the leg in all directions.

JONES' OPERATION FOR BONY ANKYLOSIS OF HIP.—In bony ankylosis of the hip following tuberculosis or sepsis, and in certain forms of coxitis, such as malum coxæ senilis, where the body weight, acting on the head of the bone, and articular friction keep the disease active, Robert Jones produces a pseudoarthrosis without disarticulating the head of the femur. This produces much less shock than does excision of the head of the bone and in suitable cases has given excellent functional results.

Make a 6-inch longitudinal incision along the outer surface of the upper end of the femur. One-half of the incision is above the mid-point of the upper border of the great trochanter and one-half is below. This cut in its lower half penetrates to the periosteum. Retract the soft parts and incise the periosteum transversely at the base of the trochanter just below the insertion of the gluteal muscles. From this line cut through the trochanter to its junction with the femoral neck, using a saw or a wide osteotome. Retract the separated trochanter upward. Open the joint and divide the neck of the femur near the head of the bone with an osteotome. Exert strong extension on the femur. Apply the cut surface of the separated trochanter to the cut surface of the neck of the femur and fix it there with a screw nail. This fixes the trochanter to the head of the femur which is still in the acetabulum. Close the wound with deep and superficial sutures. When there is much tenderness, it may be necessary to remove a section of the neck instead of merely dividing it, so as to avoid "impinging." In the case of an ankylosed sound joint, following sepsis, it may be advisable, instead of dividing the neck near the acetabulum, to divide it near the trochanter.

Arthroplasty of Knee.—This is the most difficult joint of all in which to secure perfect restoration of function. The following is the operative procedure employed by Murphy to-day: With an Esmarch constrictor high up on the thigh, two parallel vertical incisions, one on either side of the patella, are made, extending 4 in. above the joint and 3 in. below it. These incisions go through the skin only. The skin is undermined from the underlying tissues. Two lateral rectangular flaps are outlined, 2½ in. in length and breadth, from the inner and outer side of the joint, the flap including capsule, ligament, and subcutaneous fat. The base of each flap is directed downward, and is left attached to the tuberosities of the tibia, just below the line of bone division to be made later. When these flaps are dissected out the joint is freely open. Through these 2 lateral incisions the patella is freed with scalpel and chisel. The ligamentum patellæ is not divided, but it is elevated and drawn to one side. The curved chisel is then used to separate the femur from the tibia on each side, and every effort is made to restore the normal anatomic conformation of the joint surfaces. The curve of the chisel corresponds to the normal convexity of the condyles of the femur. With a smaller curved chisel the tuberosities of the

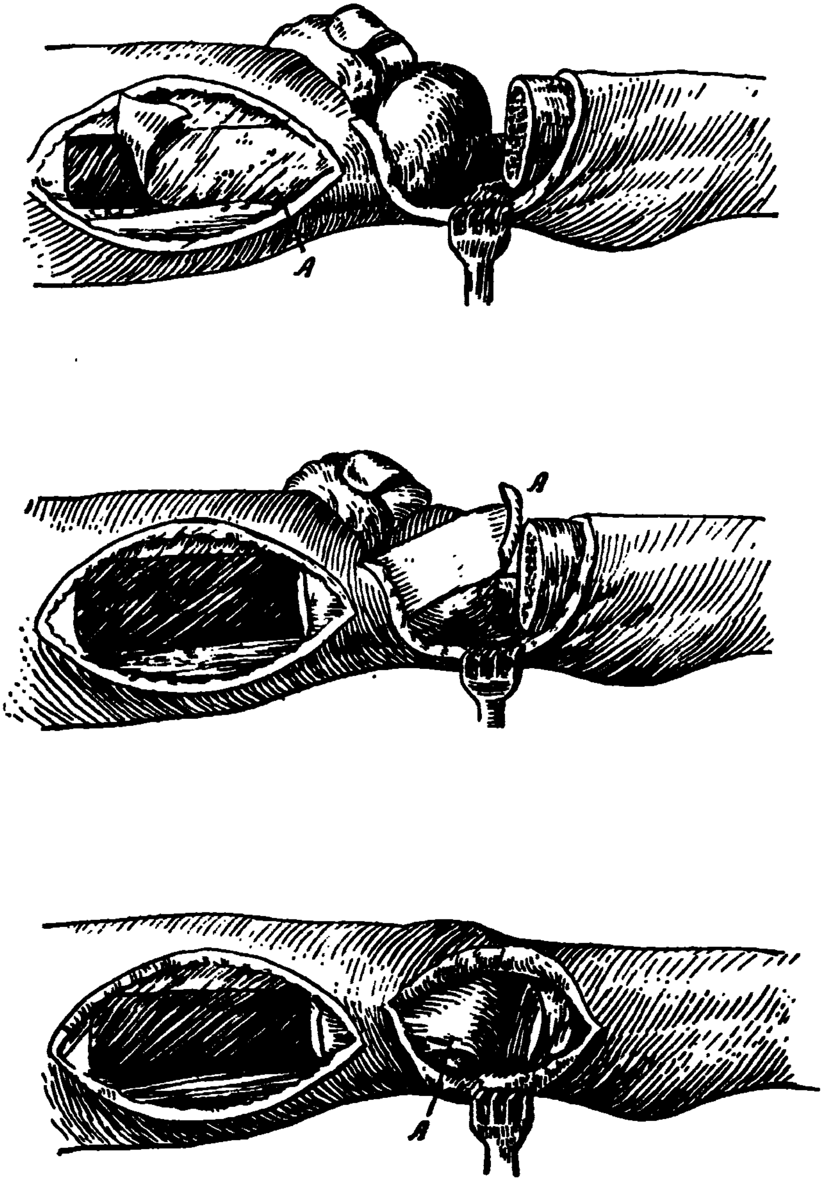


Fig. 19.—Arthroplasty of Knee. A is the pedicled flap formed out of fascia lata, reflected down and brought over the lower end of femur.

tibia are restored by excavation, making the cavity deep enough to allow the extended leg to assume a straight position without putting tension on the popliteal structures or compressing the interposed flap, and to restore the normal relationship of the femur and tibia as nearly as possible. The intercondyloid fascia and the intercondyloid ridge are reproduced, but in a slightly exaggerated degree, so as to secure stability of the new joint. The normal conformation of the anterior surface of the femur must be preserved, in order that the patella may subsequently find its natural resting place. Therefore, in doing the chiseling work, the chisel should be directed downward and inward toward the median line from both sides.

The patella has been handled in four different ways:

1. Using an interposing flap from the vastus externus or vastus internus to prevent union of the under surface of the patella with the femur.

2. Splitting it into 2 parts from above downward, and then twining the upper half under the lower half, so that the smooth fibrous aponeurotic surface comes next to the femur, making it impossible for bony union to take place.

3. Freeing the vastus externus and internus attachments to the quadriceps tendon for a distance of 2 in. above the patella; next dislocating the patella from side to side during the operation. When the limb is straightened out and the interposing flap is in position, the patella is separated from the overlying skin and fat by a blunt scissors spreading dissection, extending upward over the quadriceps and downward over the ligamentum patellæ to its attachment. A 180 rotation of the patella is made, so that the anterior surface or bursal side of the patella now becomes its articular surface and the prepatellar bursa aids in making a lining for the new joint. The anterior surface of the patella is now trimmed down with a bone cutting forceps until it is smooth and level. The vasti are then sutured to the opposite sides of the quadriceps tendon from which they are freed, to prevent luxation of the patella and a return to its former position.

4. Covering the under surface of the patella and the entire articulating surface of the femur with a fascial graft, detached from the trochanteric zone of the fascia lata, without rotation of the patella.

Murphy has had good results with all these methods. He says that the rotation of the patella is the simplest procedure. A second method (Fig. 19) of gaining a flap for interposition is one in which a pedicled flap made from the fascia lata with part of the vastus externus or internus is formed from the sides of the thigh, the base being below. The flap is made through a separate vertical incision, the bridge of the skin between the flap and the joint is tunneled and the flap turned over, and made to cover the condyles between them and the patella and the tibia.

In some cases, by reason of the numerous operations already performed about the knee joint, it has been found impossible to secure the capsular flap in the adjoining tissues. In such a case it would be advisable to take a portion of fascia lata and trochanteric bursa with the overlying fat, measuring $3\frac{1}{2}$ by 5 in., from the patient's hip and interpose it *en masse* in the knee joint, suturing it first to the posterior condyloid portion of the capsule, bringing it clear over the anterior surface of the femur and lower surface of the patella. It should be accurately sutured on both sides and ends, so that bony contact of either the patella or tibia with the femur is prevented.

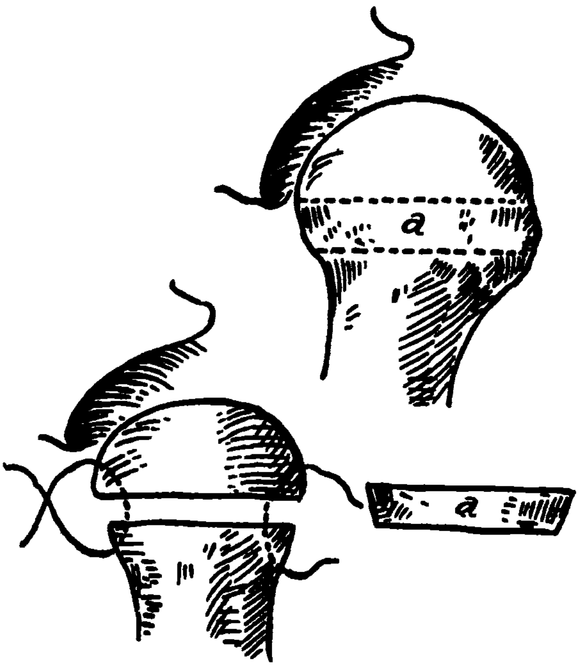


FIG. 20.—ARTHROPLASTY OF SHOULDER (Klapp). After loosening the head, a thick segment, a, is sawn out of the entire thickness of the metaphysis. The head is then united to the humerus by sutures.

An important point is that it is very necessary to form a good intercondyloid notch in the femur and to form an intercondyloid ridge and tubercle of the tibia, thus preventing subsequent luxation of the tibia. If the knee has been flexed to a considerable degree for a long period of time, it may be necessary to shorten the quadriceps tendon, which is vital to the motion of the joint.

The constrictor is removed and the wound closed without drainage. A plaster splint and a Buck's extension with a 12-lb. weight are applied. The after-treatment is the same as that for the hip.

A technic differing somewhat from the above in several joints is given by Klapp (7).

Arthroplasty of Shoulder Joint.—To avoid pedicled interposed flaps, or a resection in cases of ankylosed shoulder joint, Klapp has in 2 cases carried out the following procedure with remarkably good results. He loosens the ankylosed humeral head, then saws it off temporarily, and removes it. He then saws off a 2 cm. thick segment (Fig. 20, A) out of the entire thickness of the metaphysis, which segment is removed. He then unites the separated head to the upper humeral end by boring holes in each and suturing them. He thus makes the necessary space between the glenoid and the humeral head. In case there are found fibrous masses instead of cartilage, he recommends the covering of the humeral head with free flaps of fascia, in addition to the above procedure.

Murphy's operation is as follows: The skin and deltoid are split and its

fascia is separated along its anterior margin for a distance of 4 in. and elevated so as to expose the coracoid process with the attached heads of the biceps and the coracobrachialis. The coracoid process is divided about ¾ in. from its tip and displaced outward. A curved chisel is then used to separate the bony union between the glenoid and the head of the humerus, and an additional excavation on the surface of the glenoid is made. An incision is then made at right angles to the original incision across the chest, over the middle of the pectoralis major muscle; a flap of fat, aponeurosis, and pectoralis major muscle is then made 4½ in. long and 3½ in. wide, with its pedicle left attached to the humerus. It is swung upward and interposed between the head of the humerus and the glenoid, completely covering the bony surfaces, where it is sewn in place.

Or the head of the humerus may be divided and extracted at the level of the anatomic neck. The deltoid is cut transversely with its base attached upward, 4 in. wide, and this is interposed between the upper end of the bone and the glenoid cavity.

Arthroplasty of Elbow Joint.—Murphy makes two lateral incisions, 5 or 6 in. long, one on either side of the olecranon. The ulnar nerve should be dissected out, freed from adhesions, and elevated out of the field of operation. The incisions extend through the skin and superficial fascia. The interposing flaps are taken from the aponeurosis of the supinator longus and from the fascia and fat on the inner side of the joint with bases directed upward. The flaps are then sufficiently wide to cover the freshened surfaces of bone, and long enough to reach across from one side of the joint to the other, **or a flap may be fashioned out of the triceps (Fig. 21, A) with its fascia and reflected forward. Hoffman has had good results with covering the bony surfaces with periosteal flaps taken from the tibia. Buchmann was the first to transplant the first metatarsophalangeal joint, resected extracapsularly,** into the humero-ulnar joint. **His result was excellent. Following the latter procedure the head of the radius is removed (see Transplantation of Joints). Following the fashioning of the flaps, which opens the joint, the ankylosis, which usually exists between the olecranon process of the ulna and the humerus, is divided with a chisel and this is continued until forced mobility is secured. The anterior part of the capsule**

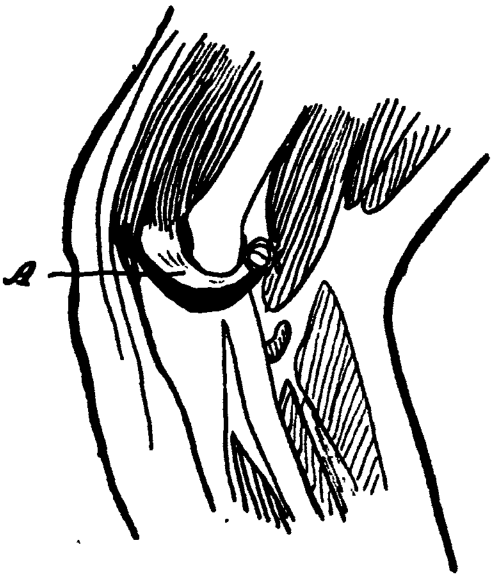


FIG. 21.—ARTHROPLASTY OF ELBOW. A is the flap formed out of the triceps and reflected forward between the bone ends.

should be fully and completely divided. The tips of the coronoid and olecranon should be removed and the olecranon fossa deepened. Ample bone should be removed from the humerus and radius to permit of free flexion and extension without force. The periosteum should be removed with the bone sections to prevent subsequent growth of the bone. Sometimes there is bony ankylosis between the head of the radius and the lesser sigmoid cavity. When this exists it is chiseled free, all exostoses are cut away so that absolute freedom of motion exists. The humerus should be rounded off so as to reproduce the normal configuration of the bone. After having secured free motion, the flaps first made are drawn into the joint and secured on all sides with fine chromic catgut. The ulnar nerve is replaced in its groove and surrounded by fat. The wound is closed.

The elbow is immobilized at a right angle, and a posterior and lateral three-fifths plaster-of-Paris cast applied. At the end of seven days the cast is removed twice a day and passive motion is begun. The arm without splints is carried in a sling after 10 to 14 days. Active and passive motions are increasingly made, and the patient carries weights to increase the extension. Massage is given every day and gas may be administered as early as the third week to force the flexion and extension, care being taken not to fracture the olecranon.

Arthroplasty of Wrist.—Only exceptionally will any one decide upon operating upon a wrist ankylosed in the straight or slightly dorsal flexed position, provided the finger movements are good. If it be ankylosed in the volar flexed position, on account of the resulting weak flexion strength, one should operate to improve the position as well as with the hope of securing some motion. If the ankylosis is the result of a tendon sheath phlegmon, then very little can be expected to result from an operation on the joint designed to give motion, except to restore the position.

Murphy gives the following technic: In case ankylosis exists between the radius and the semilunar and scaphoid bones of the carpus, a straight incision is made over the posterior surface of the head of the radius through the skin and superficial fascia. A second incision may be necessary over the styloid process of the ulna. The flap to be interposed is V-shaped with base upward, and is taken from the deep fascia and the joint capsule. This flap is lifted upward, exposing the ankylosis. This is freed with a chisel, sufficient bone being removed to give free motion. The natural conformation of the bone is restored as nearly as possible. It may be necessary to remove most of the first row of the carpal bones, as well as a slice from the radius and ulna. When free motion is obtained—that is, perfect flexion and extension—the previously formed flap, consisting of deep fascia and the joint capsule, is pushed down between the carpal bones and the head of the radius to the joint depth and is sutured with chromic gut to the posterior surface of the anterior capsule of the joint, and laterally to the periosteum of the bone. The wound is then closed as usual. The after-treatment is the same as in the previous operations.

If the ankylosis has been in volar flexion, when the hand is straightened, it may be that the extensor tendons are found to be relatively too long. In such a case it is essential for subsequent good motion of the joint to shorten the extensor tendons of the fingers and wrist. This is best accomplished by dividing the tendons and overlapping them without excising any portion of their length, following which they are sewn side to side. It will not essentially delay the early motions of the joint if this method be employed.

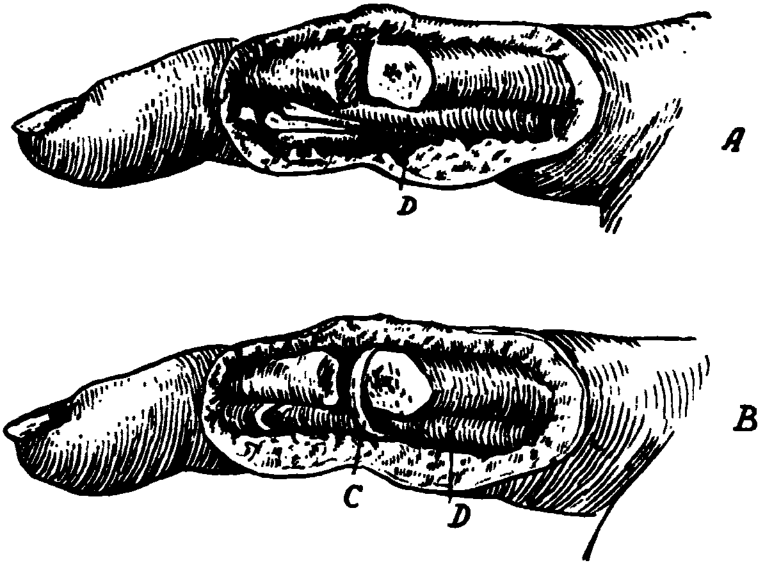


FIG. 22.—ARTHROPLASTY OF FINGER JOINT. C is the flap of tendon sheath D interposed between the bone ends.

In case a flap to interpose be difficult to obtain in the neighborhood of any joint, Murphy emphasizes the value of the trochanteric fascia or the fascia lata with the trochanteric bursa. Such a free flap works admirably.

Arthroplasty of Finger Joints (Fig. 22).—Reports on this procedure are very scarce in the literature, strange to say, when one considers the importance of the subject. That the condition of the tendons, whether adherent or not, is the important point cannot be denied. In many cases this cannot be told until the joint is opened. In case the finger is ankylosed in the fully extended position, an attempt should be made to mobilize the joint before acceding to the request that it be amputated. No harm can be done if asepsis is maintained, and even if a subsequent second ankylosis takes place, if the finger be in the useful flexed position, nothing but good can result. The joint is exposed by a lateral incision and the ankylosed bone ends chiseled away sufficiently to allow of free motion. Then a piece of free fascia is inserted between the ends where it is sutured, or a flap is made on the palmar side from the tendon sheath (Fig. 22, C) with base of attachment upward. This is brought over the bone ends, where it is sutured anteriorly. This procedure is best adapted to the thumb, though it may be used in any finger.

Murphy has used the same method of procedure in ankylosis of the metatarsophalangeal joint of the great toe. The flap of fat and fascia was dissected loose from the inner side of the foot, its base being upward, and this was interposed between the freshened bone ends. Mayo has used the same technic in the treatment of bunion.

Arthroplasty of the Temporomaxillary Joint.—The best procedure is that of temporary resection of the zygoma, devised by Lilienthal. A horizontal incision is made along the zygoma, extending back to a point in front of the auricle, and thence down in front of the ear toward the angle of the jaw. The horizontal incision passes down to the periosteum of the zygoma; the vertical incision is 4 cm. long, and passes only through the skin, avoiding the subcutaneous structures. The triangular skin flap is dissected free and retracted downward and forward. This exposes the zygoma. By means of a wire saw, passed under the zygomatic arch, the zygoma is divided in 2 places anteriorly and posteriorly. This division of the bone is made obliquely to the long axis of the zygoma, the anterior section passing upward and forward, and the posterior section passing upward and backward, so that when the segment is pressed back into position it cannot be drawn down by the masseter. The resected zygoma is then retracted downward, carrying with it the attachment of the masseter muscle, the upper end of the parotid gland and the fibers of the facial nerve and connective tissue, thus exposing the articulation. Upon replacing the resected zygoma, it is held firmly in place by the contraction of the masseter and requires no suture.

The ankylosis may be both articular and extra-articular combined, unilateral or bilateral, and the degree of bony fixation may extend forward from the joint and include the zygoma and coronoid process. It may be necessary to detach the temporal muscle from the coronoid process, whose tip may be attached to the base of the skull, requiring its removal as well as removal of the head and neck of the jaw. When motions are free, a flap is taken from the temporal fascia with base downward, and this is turned over and interposed through the joint where it is sutured. The after-treatment is most important and should be perseveringly persisted in. A wooden wedge should be shoved in between the teeth and maintained there most of the time, in an endeavor to increase the extent of motion.

PREVENTION OF ANKYLOSIS BY INJECTIONS OF OIL

Adhesions in joints may often be prevented by injecting sterile olive oil. This procedure is especially indicated after the breaking up of fibrous adhesions, in order to prevent their reformation. Baer has found that joints will tolerate as much oil as they will hold, and that when filled, passive motion is less painful. The oil should be at body temperature, and the needle should inflict the least possible trauma.

False Ankylosis

Operation for ankylosis due to adhesions and contractures of soft tissues need not necessarily involve the bone. Non-osseous ankylosis demands operation when it is not amenable to treatment by passive motions or oil injections. Division or plastic elongation of tendons and muscles is often indicated. For ankylosis of the patella a portion of the capsule above the patella or a flap from one of the vasti laterally may be made and reflected inward so as to cover the posterior surface of the patella. Murphy has shown that in ankylosis with fixation of the capsule to the head and neck of the bone, with contracture of the capsule, the capsule with the involved ligaments may be excised, and the head and neck of the bone covered with aponeurosis or muscle turned in from the neighborhood. He has shown that division of the capsule without its excision does not suffice. Motion free from tension must be secured, even to the point of flail motion. In the knee, when ankylosis is due to involvement of the capsule and ligaments in inflammatory tissue, and these structures are contracted and inelastic, all of the peri-articular ligaments and the capsule, excepting the hamstring tendons, the quadriceps, the patellar ligaments, and the crucial ligaments, should be dissected away.

ARTHRODESIS OF JOINTS

This operation aims to produce ankylosis by a bloody operation. The procedure should not be done in children under eight years of age on account of danger of injuring the epiphyses.

Arthrodesis of Shoulder Joint.—When the shoulder is flail as a result of paralysis, with the muscles of the hand, elbow, and those uniting the scapula to the trunk still active, this procedure may be useful. If the elbow muscles are, in addition, paralyzed while the hand muscles are active, arthrodesis of both shoulder and elbow may be indicated.

If the deltoid and circumflex nerves are degenerated, the incision may be made where thought best, disregarding the deltoid. Just internal to the acromioclavicular joint make the incision downward to the outer side of the pectorodeltoid groove, cut the capsule along the bicipital groove, excise as much of the synovia as possible, and scrape the remainder thoroughly. Dislocate the head of the humerus out of the wound, which is usually easy. Remove all cartilage from the head of the bone and from the glenoid cavity and freshen the approximating surface of the acromion process. With an assistant holding the scapula in good position, the humeral head is approximated to the glenoid cavity and acromion process with the arm slightly internally rotated, abducted (45°), and brought forward somewhat. The bone is fixed in this position by means of 2 wires, one between the humerus and the upper part of the glenoid and the other between the humerus and the acromion. The slack in the capsule is taken up, and the arm immobilized in a plaster splint. Immobilization should be kept up for two months at least.

Arthrodesis of the Elbow Joint.—It may become necessary to operate in case a flail joint results after excision of the elbow. In cases of paralysis, when no hope exists of obtaining a useful joint after tendon transplantation or of nerve anastomosis, it may likewise become necessary to operate for the useless flail joint. A thin shell of bone is removed from the humerus and the forearm bones. The sawn surfaces are brought into good apposition and are maintained till bony union takes place in the position of flexion, to such an angle that the fingers may be brought up to the mouth. In cases in which both the shoulder and elbow are flail but the muscles of the hand are active, one may perform arthrodesis of both the shoulder and elbow, or one may adopt Robert Jones' expedient of excising a diamond-shaped area of skin from in front of the elbow, with the apices above and below. The two apices are sutured together, which produces an acute flexion of the forearm, where it is maintained.

Arthrodesis of the Wrist.—To remedy a flail wrist joint due either to paralysis or after a resection is a rare necessity. A radial or ulnar incision will suffice for the joint exposure and the freshening of the joint ends. The position the wrist is to be put in is one of dorsal flexion, in order to afford the best subsequent use of the flexors. The bones may be nailed together or a bony graft may be inserted between them.

Arthrodesis of the Hip.—This is best accomplished by Albee's procedure, which see.

Arthrodesis of the Knee Joint.—Relaxed knee joints, with loss of control, especially those due to infantile paralysis, have been stiffened by resection, but this results in shortening. Hibbs (6) makes a transverse incision just below the patella, divides the patellar ligament, and turns the patella upward. The patella is then denuded of cartilage and the front of the femur and tibia similarly treated, thus making a bed to receive the patella. The crucial ligaments and the epiphyseal lines should not be harmed. The periosteal edges are stripped from the patella and the bone fitted into its bed. The edges of the periosteum are then laid over the freshened surfaces and sewed to the periosteum around the edges of the tibia and femur. A plaster splint is applied and worn for 5 months, the patient being allowed to walk with the splint on after 4 weeks. The patella becomes united to the femur and tibia and its stripped off periosteum produces still more bone to solidify the union.

Arthrodesis of the Ankle Joint.—This may be accomplished by the usual resection of the ankle, preferably with the Kocher outer long incision. If the joint be dislocated, one removes the cartilages from the astragalus and tibia thoroughly, including the sides of the astragalus and inside surfaces of the malleoli. Nailing or bone sutures are usually not necessary. Contracted tendons should be divided, particularly the Achilles tendon. Hoffa assured the result of the arthrodesis by forming a pedicled periosteal bony flap with base below, which he obtained from the posterior tibial surface, and reflected this downward under the os calcis, where it was fastened. Cramer took a 7 cm.

long periosteal bony flap from the anterior surface of the tibia, which he turned downward.

Lexer has inserted a bone graft (dowel) through the ankle. Upon the sole of the foot a small incision is made down to the bone. The edges are retracted, and a large drill is inserted through the os calcis and astragalus into the tibia. Through this drill hole is driven a bone section with periosteum taken from the fibula. Experience has shown that the portion of bone graft driven into the bone becomes absorbed in from 6 months to a year with a resulting return of motion.

Whatever operation is used, the foot should be immobilized in the right-angled position for 3 or 4 months.

PLASTIC OPERATIONS ON JOINTS, INCLUDING TRANSPLANTATION OF ENTIRE JOINTS

To the plastic operations belong the lessening in size of the too lax capsule. An elliptical excision of the exposed capsule may be made with following suture or an incision of the capsule may be followed by the overlapping of one edge over the other and then suturing them in this position. For further treatment of this subject see 16 under Bibliography.

TRANSPLANTATION OF ENTIRE JOINTS

Transplantation of Metatarsophalangeal Joint. Buchmann in two cases has transplanted the first metatarsophalangeal point into the elbow for bony ankylosis. A posterior longitudinal incision is made down to the triceps tendon and the olecranon. At the outer side of the olecranon divide all soft parts longitudinally. With an elevator separate and push inward the triceps tendon, remnants of capsule and periosteum. Divide the olecranon at the level of the joint and the lateral remnants of capsule. Divide the bony union between the humerus, radius, and ulna. Flex the elbow and cut out from the trochlea a niche, wider in front than behind and narrower above than below. Remove a very thin slice from the lower end of the humerus. Separate the brachialis anticus from its insertion into the coronoid process. Cut a quadrangular niche in the ulnar epiphysis. Remove the head of the radius and separate the radius from the ulna. Excise the first metatarsophalangeal articulation without opening the joint itself. Remove with the joint sufficient metatarsus and phalanx to fit into the niches cut in the humerus and ulna. Implant the excised joint into the wound at the elbow in such a manner that its plantar surface faces backward. Fit the end of the metatarsus and the phalanx into the corresponding niches cut in the humerus and ulna. Close the wound in the elbow and immobilize in the extended position.

Transplantation of the Entire Knee Joint.—Lexer (8), in 1908, described two cases in which he transplanted the entire knee joint. In one of these cases he obtained the graft from a cadaver 8 hours after death. It healed in without any disturbance or fistula formation, but so much connective tissue formation was produced that the subsequent movements were very much hindered, which required the removal of the graft and the substitution for it of a joint taken from a freshly amputated leg. Lexer therefore warns against taking a joint from a cadaver and obtains it from a limb amputated for either senile gangrene or paralysis. His technic is as follows: Without constriction of the extremity above, a large flap is formed in front, with its convex lower end below the tuberosity of the tibia and with the lateral vertical prolongations upward along the posterior aspect of the joint. The remnants of the ligamentum patellæ and the joint capsule are turned upward with the flap. The subsequent skin scar should not come in contact with the subsequent graft. After exposing the joint, the soft parts, including tendon insertions, are separated from the bones, both laterally and posteriorly, by sharp and blunt dissection. The cicatricial periosteum is removed with the bones; if possible to retain portions of it, these are fastened later to the transplanted graft. The femur and tibia are sawn across, the defect resulting being about 3 fingers in width when the limb is straightened. The assistant stops the capillary bleeding through compression. The knee is now excised from a freshly amputated limb, sufficient bone from the femur and tibia being removed to fill the defect. The entire articular surfaces, including the crucial ligaments and the lateral insertions of the capsule, are retained and also the semilunar cartilages, if possible. The graft is inserted as quickly as possible without immersion in any solution. The remains of the periosteum are brought over the graft where they are sutured. The graft is now not fixed by any foreign body such as a nail or a wire. If thought best, it may be fixed by a living bone graft, a dowel, but this is apparently not necessary. The ligamentum patellæ, if preserved, is fastened to the periosteum. If it be gone, a new one should be formed from the front of the quadriceps and reflected downward, where it is fastened to the periosteum. If the patella must be separated from the femur with the chisel, which is usually the case, then between the freshened surfaces of the patella and the femur a fascial flap must be fashioned from the neighborhood (as in arthroplasty, which see), and this must be reflected between these freshened surfaces to prevent their subsequent adherence. There seems to be no decision as to the necessity of transplanting the synovial membrane as yet. Lexer's oldest joint transplantation, which was grafted without the synovial membrane, shows fine movements (8). Finally the graft is sewn into place with great care, ligaments and tendons being accurately sutured to the graft.

WOUNDS OF JOINTS

For purposes of treatment joint wounds may be divided into punctured and incised. It is generally safe to regard punctured wounds of joints as not infecting the joint itself, since the probability is that any organism upon the instrument will be wiped off during the passage through the skin and subcutaneous tissues. The skin about the puncture spot should be thoroughly disinfected with tincture of iodin. No probe should be used, since it may carry infection from the surrounding tissues into the joint. If there seems a probability that the subcutaneous tissues have been infected, the puncture may be enlarged so that the subcutaneous tissues may be disinfected with tincture of iodin. The joint should not be opened. The wound should not be sutured. Wet sterile dressings (a solution of 25 per cent. alcohol) are applied and over this a smooth layer of cotton. A posterior moulded plaster splint should immobilize the joint. Elevate the limb and carefully watch the pulse, temperature and pain. An effusion almost always appears. If the temperature does not go above 110° F., nor the pulse above 100, and the pain is not severe, no anxiety should be felt. If the effusion be very great, aspiration may be advisable and the fluid may be examined for septic organisms. If all goes well, motions should be attempted in about 10 days or after the effusion has been absorbed. If the temperature and pulse run higher, if pain is severe, and if there is any suspicion of a chill, infection is present. If the progress is not rapid, the joint should be aspirated and injected with a 2 per cent. formalin in glycerin solution, which is at least 24 hours old. If the progress is rapid, no time should be lost in opening and draining the joint. Remove the drains as early as possible and begin motion.

If the patient is not seen until a septic arthritis has undoubtedly occurred, the most extensive drainage should be employed. In some severe cases a resection may be required, in which case the raw bone ends should be swabbed over with pure carbolic acid to prevent an osteomyelitis developing. In the worst cases an amputation may be required to save life.

Incised wounds of the joint should be treated as though they were already infected. Ether should be administered and the subcutaneous tissues should be swabbed thoroughly with tincture of iodin. A sponge should then be placed in the wound and the skin disinfected with tincture of iodin, beginning at the wound edges and working away from the wound, thus preventing the washing into the wound of any infection from the surrounding tissues. After the superficial parts have been disinfected, the interior of the joint should be inspected, after enlarging the opening in the capsule, if necessary. Thorough washing out of blood clots and other material with warm sterile salt solution should follow. Drainage with perforated rubber tubes should follow through the incision or through supplementary ones. Continuous irrigation should be established as the after-treatment. If all goes well, the symptoms subside and the drains are removed in from 3 to 5 days.

Contused Wounds.—Here the soft parts superficial to the joint are lacerated and bruised and there is marked soiling of the wound. The main types of this injury are machinery accidents, in which the tissues are lacerated and soiled by dirt or grease, and compound dislocations, in which the bones will be soiled by contact with the clothing or by contact with the ground. A general anesthetic should be administered and thorough disinfection should be carried out. The contused, soiled, lacerated tissue edges should be cut away and tincture of iodin applied to all the surfaces. The dislocated bones should not be reduced until they have all been thoroughly douched with tincture of iodin. If they have been already reduced, the dislocation should be reproduced and the bone ends cleansed. If necessary, portions of bone or cartilage, into which dirt is ground, should be shaved off with knife or chisel. The skin should be cleaned with tincture of iodin, proceeding away from the wound. The joint cavity is irrigated with sterile salt solution. Large drainage tubes are introduced into the joint through the wound and through counter openings, so as to drain every recess. The rent in the capsule is not sewn up. The joint is immobilized, and continuous irrigation employed.

DISEASES OF BONES

GROWING PAINS

During the growing period, particularly between 13 and 16 years of age, young adults often complain of pains of varying intensity in bones and joints, popularly termed "growing pains." These are due to congestion of the medulla in the neighborhood of the epiphyses. There may be an elevation of temperature and the condition is more than likely to be confounded with commencing bone or joint disease.

Treatment.—A careful attitude is the wisest. The patient had best at first be treated as though there were some serious affection of the bone or joint developing. He should be kept in bed and the limb fixed on a splint. Fresh air, good food and warmth will help materially. If the case be one of simple congestion, the pain and stiffness soon disappear and no swelling becomes visible. In true joint disease, muscular rigidity and wasting persist. A radiogram may be of value in the differential diagnosis.

ACUTE INFLAMMATION

There are three structures which make up a bone, periosteum, bone itself and the medulla. Inflammation of all these three structures probably occurs in most cases of inflammation, although a particular name may be given to the structure principally involved.

Acute Periostitis

A trauma on the tibia, for example, may produce a subperiosteal hematoma. This may become absorbed or go on to the formation of an abscess, which, if not properly treated, may lead to necrosis of a portion of the shaft. Bone may be laid down in the raised-up periosteum, producing a permanent unevenness. All skin abrasions over the hematoma must be kept clean by wet antiseptic dressings so that the hematoma may not become infected from them. Even pressure by a rubber bandage should be applied, but no pain should be caused by it. Should the hematoma become infected, an incision should be made through the periosteum and the abscess cavity drained. A persisting sinus in such a cavity means necrosis of the bone, which will require the removal of the dead bone. The acute periostitis described by Ollier as "albuminous periostitis," which is characterized by a serous or albuminous exudate beneath the periosteum, is probably due to mild infection.

ACUTE SUPPURATIVE OSTEOMYELITIS AND PERIOSTITIS

The infecting organism is most frequently the staphylococcus pyogenes aureus, more rarely the streptococcus and the staphylococcus pyogenes albus. The typhoid bacillus and the gonococcus may likewise cause the disease. The acute infectious diseases which frequently precede an arthritis may likewise produce an osteomyelitis of the shaft above the affected joint, or it may occur spontaneously (i. e., through the blood into the medulla), in which case it is most common between 10 and 14, affecting boys more frequently than girls. The disease generally begins in the medulla in the neighborhood of the epiphyseal line, its commonest seat being the lower end of the femur, the upper end of the humerus and tibia, and the lower end of the radius. Of the short bones, the os calcis is most frequently affected. The traumatic form, as after fractures, may occur at any age and in any bone.

The prognosis is always grave, both as regards the immediate and the final result. The probability is that the patient will have a long illness, that there will be serious derangement of the neighboring joints, that fistulæ will develop and persist, that portions of the bone will die, requiring subsequent operations for their removal, and that, when the epiphysis is affected, difference in growth and deformity will result, the exact amount depending upon the extent of the disease and the age of the patient at the time of the attack.

Treatment of Acute Suppurative Inflammations of Bone.—ACUTE SUPPURATIVE PERIOSTITIS.—Acute suppurative periostitis without any infection of the medulla does undoubtedly occur. The general symptoms are not so severe as those of acute osteomyelitis and the swelling and redness appear sooner. The acutest spot of tenderness should be cut down upon, the periosteum split and the pus evacuated. The question of whether the medullary cavity should be opened or not at once may be difficult to decide in some cases. If shortly after the onset there is a considerable collection of pus beneath the periosteum, and if, after wiping the surface of bone free from pus, there is no oozing of pus from innumerable points on its surface, no soft spot in the bone, no opening in the bone, or no fat free in the pus, then one may delay opening the medulla at once and await the result. A couple of drainage tubes should be inserted under the periosteum and these packed about loosely with gauze. If, after 24 or 36 hours, there is no amelioration in the symptoms, particularly in the pain, then the medulla should be opened up without delay. If the symptoms subside, then healing will take place rapidly if necrosis does not occur. A drainage tube is allowed to remain in place until it is pushed out by the granulations. If a sequestrum is going to form, it will manifest itself partly by the persistence of a sinus and partly by the presence of bare bone which can be felt with a probe. But it must not be assumed that a sequestrum will necessarily separate in cases of acute periostitis because bare bone is felt for 2 or 3 weeks after the abscess has been opened. If the bone continues bare for 6 weeks or longer, the probability is that a sequestrum will have to be removed later on. The difference between these two conditions is that in the case where the bone is living, its surface becomes covered with granulation tissue, which is soft and velvety to the probe, while the bone which has died does not become covered with this granulation tissue, and hence preserves its tough, hard feel.

ACUTE SUPPURATIVE OSTEOMYELITIS.—The patient, usually young, is acutely sick. He may have had a slight injury, have taken cold, or have just had one of the eruptive fevers. He is much prostrated, is often delirious, with a high temperature, and complains of exquisite localized pain and tenderness in some bone, for example, just above the knee. Often in such a case the pain may be mistaken for pain in the joint itself. The local point of tenderness is our only guide to the seat of disease and should be accurately outlined by the operator before the anesthetic is administered. There is very apt to be some swelling as well as pain. *Radiography will be of no assistance in the early diagnosis*, as the changes in the bone are so slight that nothing is shown by the picture.

The great desideratum is to give exit to the pus which is under pressure in the medullary cavity. A free incision is made in the soft parts directly over the point of greatest tenderness, avoiding important structures, and the periosteum is freely incised lengthwise. If it seems probable that the medulla is involved, the bone is chiseled away, so as to expose the medulla. There are many cases in which one will be uncertain as to whether the original infection lies under the periosteum alone or in the medulla, particularly if the operation is undertaken early in the disease. If drops of free fat be observed under the periosteum, or if, after wiping the surface of the bone free of exudate, there appear minute droplets of pus, if the bone seems softened over some area, or, in advanced cases, one finds a small sinus exuding pus leading into the bone, then one should not hesitate to open the medulla. If in doubt, one may split the periosteum and wait for 24 or 36 hours to see if the symptoms will abate. Instead of the chisel, a trephine may be used. The medullary cavity should be opened by removing bone up and down as far as the abscess extends. Remove all the diseased tissue with a curet and swab the cavity out with pure carbolic acid, followed by a neutralizing alcohol solution (pure). Provide for drainage by perforated rubber drains, surrounded by a loose packing with gauze. Leave the wound wide open.

During the operation no focus of disease may be recognized. This does not by any means signify a mistaken diagnosis. It means that the surgeon has anticipated the gross appearance of disease, or that the focus has not been reached. It is proper to make a further search for the focus of disease by drilling subsidiary openings at different levels. If after this no focus is found, drainage should be provided for. If gross pathologic changes are present, but have not been discovered, it is certain that the pus will make its exit through the opening made by the surgeon. If the operation is performed before gross pathologic changes have occurred, the drainage provided may lead to resolution. If a subperiosteal abscess is discovered on the popliteal surface of the bone, the medullary cavity will have to be opened on the side. If the patient is in good condition, it is advisable to remove all the bone which is apparently dead or dying. This will hasten the healing, since, if all the dying bone be removed, there will be no subsequent sequestrum formed requiring removal.

After-treatment.—The limb should be put on a splint which immobilizes the joints above and below. Daily dressings should be done. As ordinarily applied, they are very painful because the dry gauze adheres to the overlying soft parts. This adhesion can be avoided by coating the raw soft surfaces with sterile vaselin or boric acid ointment. The bone itself is insensitive or nearly so.

The fixation should be continued only until the subsidence of the acute symptoms when daily passive motions should be instituted in order to prevent ankylosis. Unless the joint itself be affected, the subsequent stiffness is usually due to inflammatory (lymphatic) swelling of the tissues about the joint, particularly of the muscles in the vicinity of the joint, which may become matted together; hence the advantage of early movements. Should any portion of the bone die, as evidenced by persistent sinuses, healing will not take place until the sequestrum has been removed. In all operations for osteomyelitis none of the periosteum should be removed. It should be split and reflected off the bone. The periosteum is our mainstay for the subsequent re-formation of new bone.

Among the chief risks of acute osteomyelitis are septicemia and pyemia, from which, despite early and free operation, the patient may die. In such cases, the only prospect for life lies in an amputation, notwithstanding its seriousness.

Resection of the Entire Diaphysis.—The periosteum of the entire diaphysis may be separated from the bone from end to end, in which case the whole shaft will die. This does not demand amputation because excellent results have been obtained by removing the whole dead diaphysis, particularly if the periosteum be preserved. The entire length of the periosteum should be split, and, in many cases, all that is necessary is to lift out the dead shaft. In other cases there will be places in which the periosteum is still adherent. The periosteum in such a condition should not be peeled off by itself but should be chiseled off, leaving attached to the periosteum a thin layer of bone. This will give the best chance for the subsequent formation of new bone. Should the diaphysis still be adherent to the epiphysis, a piece of the adherent diaphysis should be left attached to the epiphysis in the hope that a portion of the epiphyseal cartilage may remain undestroyed. After removing the dead shaft, the edges of the previously split periosteum should be sutured, leaving several places into which drainage tubes may be inserted. Sometimes the shaft may be almost completely reproduced, particularly if a layer of bone has been chiseled off under any adherent periosteum. In other cases this does not happen because the osteogenetic layer of the periosteum has been destroyed by the inflammation. In such a condition in a child it becomes a question whether anything short of amputation will be of use, since the epiphyseal cartilage is usually destroyed in these cases and no further growth will ensue. The answer will depend very much on the particular bone infected.

In cases where the entire diaphysis is gone, the question of the subsequent advisability of bone grafting will come up. This should never be done until the limb has been entirely healed for some time, at least a month, since infection ruins a graft. The graft should always be taken with periosteum covering at least one surface, and should be obtained from the patient himself, fibula, tibia, and ulna (see Bone Grafting). There is very little to justify taking the graft from a cadaver, an animal or even from another person, since the changed serological relations will most frequently lead to an absorption of the graft. It is not necessary that the graft be of the same thickness as the original bone, since, if the graft remain alive, it will increase to a size commensurate with the demands put upon it. Thus, a small piece of the fibula put into a defect in the tibia will subsequently increase in size to the size of the normal tibia, as occurred in one of my own cases. (For Methods of Bone Grafting, see page 494.)

ACUTE EPIPHYSITIS.- When an osteomyelitis occurs near the epiphyseal end of a bone in a child, the epiphyseal cartilage will probably be completely destroyed and no further growth of that end of the bone will subsequently take place, resulting in material shortening of the limb. The treatment of all the stages of acute epiphysitis is identical with that for acute osteomyelitis, excepting the treatment for the resulting deformity, which consists not only in shortening of the limb but, when one of two parallel bones is affected, further troublesome deformity. If, for example, the epiphyseal cartilage of the tibia or the radius be completely ruined, the unaffected neighboring bone continues to grow, and the foot or hand becomes deflected to the side of the damaged bone. When the disease occurs in infancy, complete uselessness of the hand or foot may result. In order to prevent this, it has been suggested that the epiphyseal cartilage of the healthy bone be destroyed. This would be the rational thing to do if one could be sure in the early stage of the disease that the affected cartilage was actually destroyed, but this is impossible. One should wait for 2 or 3 years to see whether the cartilage is alive or not. If, after this time, no growth occurs and deformity is commencing, then it is advisable either to destroy the corresponding epiphysis of the other healthy bone or to excise portions of the growing bone so as to make the hand or foot straight again. The question when to operate will depend on the age of the patient at the time of the beginning of the attack. If the time between the attack and that at which growth normally ceases is short, then one may wait before operating, but the deformity should not be allowed to become too great. If several years must pass by before growth ceases, then there is no advantage in waiting, because the joint surfaces, tendons and muscles will become so altered in accommodating themselves to their new positions that there will be great difficulty in righting them. Consequently, if the deformity is not yet marked, destruction of the healthy epiphysis may preferably be done or portions of the growing bone may be excised. The latter procedure may be repeated if necessary. If when the deformity is first seen it is marked, nothing can be done but excision of part of the healthy bone combined with possible destruction of the cartilage. To destroy the cartilage, all that is necessary is to chisel through the thin plane of cartilage and remove a very thin slice of it.

When an acute epiphysitis occurs, one of the serious consequences may be a separation of the epiphysis from the shaft, with dislocation, a condition which should be carefully watched for and prevented by careful splinting to prevent subsequent union in a faulty position. Murphy of Chicago has suggested, as a measure to prevent the deformity resulting from a dead epiphysis, the chiseling away of the end of the bone whose epiphyseal cartilage has been destroyed and the insertion of a bone graft in its place containing a similar line of cartilage from the bone of another child.

ACUTE OSTEOMYELITIS ACCOMPANIED BY JOINT SUPPURATION.—An effusion into a joint in the neighborhood of an osteomyelitis is not uncommon. While this remains uninfected, no operation on the joint should be done. An elastic bandage should be applied. In cases of doubt, repeated aspirations with the strictest sterilization of the skin should be performed and the doubt cleared up. If the patient is not very sick, free drainage of the joint should be instituted at once on the appearance of pus in the aspirated fluid. If the symptoms do not improve rapidly under this treatment, amputation must be performed without loss of time in order to save life.

When the joint becomes infected, it is frequently in association with an acute epiphysitis, and, if the patient be young and recovers, in association with a disorganized joint there will result lack of growth, which will ultimately produce a useless limb. The question is, therefore, at the very start of the disease whether immediate amputation is not the best treatment. If the patient be seen in a severe septic condition, there should be no hesitancy in amputating immediately above the affected joint.

ACUTE SUPPURATIVE OSTEITIS OF THE FLAT BONES.—This is not uncommon in the skull, scapula or bones of the foot. It usually occurs after an open wound in these bones. The prognosis is very bad in acute suppurative osteomyelitis of the skull. The treatment is the same as for the condition elsewhere (see Inflammation of the Cranial Bones). When the whole scapula is affected, complete excision (see Excision of Individual Bones) is the best practice. When only a portion is involved, all the bone visibly affected should be cut away. In the case of the tarsal bones, or other small bones, excision of the

affected bone should be adopted if the inflammation be limited to it. There is often suppuration both of bones and joints, as after compound fractures or injury to the joints, in which case an ultimate amputation will probably be necessary.

CHRONIC OSTEOMYELITIS AND PERIOSTITIS

In chronic periostitis there is great thickening of the periosteum with new formation of bone beneath it. In chronic osteomyelitis there is either softening of the bone, termed rarefying osteitis, or condensation, termed condensing or sclerosing osteitis, or there may be localized suppuration called "Brodie's abscess of bone." After a time the inflammation extends to the periosteum. This inflammation may be chronic from the start, sometimes occurring after an injury. In many cases fistulæ develop and eventually pieces of bone are discharged from them. In some cases the impediment to healing consists in the sclerosing bone, which will neither provide healthy granulation tissue to obliterate the abscess cavity nor permit its walls to collapse.

Treatment.—The periosteum over the whole area of thickening is divided and separated from the bone beneath. The new periosteal bone is gouged or chiseled away over the same area, and an opening is carried through the bone into the medullary cavity, where any abscess which may be present is opened. Dissect out the diseased lining of all fistulæ. Scrape out the medullary tissue and disinfect the cavity with pure carbolic acid. With chisel and mallet cut away the sclerosed bone from around the site of the abscess until healthy bone is reached. To sterilize the cavity apply tincture of iodin liberally to all its surfaces. If little infection of the cavity is evident, after thorough disinfection, the cavity may be allowed to fill up with blood clot and the skin closed without drainage. If the cavity be evidently infected, it may be wise to pack it lightly, possibly closing some of the wound about the pack. Or the cavity may be fitted with Mosetig-Moorhof's bone plug, or sufficient of the bone of the walls of the cavity may be removed so that the skin edges can be made to go to the bottom of the cavity, where they are nailed. Various plastic operations designed to fill bone cavities are described later on.

The limb should be placed on a splint and kept at rest for 3 or 4 weeks. Unless rest be enforced, the delicate clot which fills up the cavity is apt to break down.

SEQUESTROTOMY.—**The process of separation of the dead bone may take from 6 weeks to 6 months.** While separation is going on, new bone (involucrum) is formed from the periosteum, sometimes to such an extent as to completely inclose the sequestrum as in a shell. Openings called "cloacæ," leading to the sequestrum, are left here and there in the new bone. This new bone prevents the casting off of the necrosed bone without operation. **It is wise before removing the sequestrum to wait until sufficient new bone has been formed to maintain the continuity of the bone, unless the inflammation and sepsis kept** up by the dead bone are so great as to endanger life, in which case no delay in removing the sequestrum is permissible.

Nichols recommends that the sequestrum be left in place just long enough to provide for the laying down by the periosteum of sufficient new bone to hold the limb in shape after the sequestrum is removed. This period is roughly 8 weeks in the case of a bone that has a companion parallel bone, such as the tibia and radius, and 16 weeks in other bones. In the former class, the thickness of the new periosteal bone is determined not only by radiographs, but by thrusting a needle through the periosteum near the opening of the sinus. If the bone crackles like an egg shell when the needle passes through it, it is strong enough to justify the removal of the sequestrum.

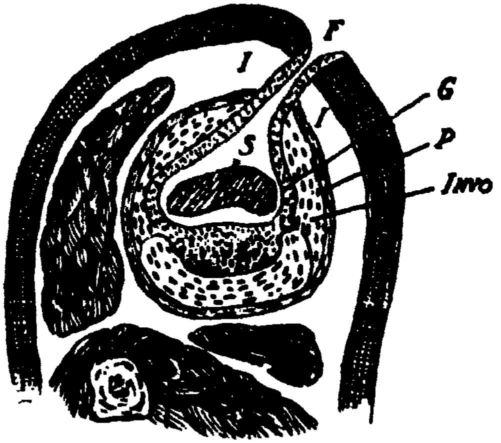


FIG. 23.—SEQUESTROTOMY (BINNIE) (1). S is the sequestrum. G, layer of granulation tissue, P, the periosteum, Invo, the involucrum, F, fistulous opening.

REMOVAL OF THE SEQUESTRUM.—With a radiogram as a guide, plan the incision so as to avoid important structures, more particularly nerves, and to expose the whole length of the diseased area. The incision may be made through openings of one or more fistulæ or may be independent of these. All the soft parts, including the periosteum, are divided down to the bone, and the periosteum is separated from the bone with an elevator for about ½ in. on each side of the longitudinal incision. The soft parts, including the periosteum, are then retracted. If the sequestrum is entirely superficial, it is removed. If the sequestrum be deep and inclosed in a shell of new bone (involucrum), the new bone is gouged or chiseled away, beginning at one of the cloacal openings in the new bone, until the whole length of the sequestrum is freely exposed. No attempt should be made to extract it through a small opening, since a fracture of the sequestrum may occur and fragments may be left behind, which will be difficult to find afterward and will prevent the wound from healing. Remove the entire sequestrum, cutting it from the living bone, if necessary, with the chisel. Sterilize the cavity by the curet and application of pure carbolic acid and alcohol. Follow this by applying tincture of iodin, and endeavor to obliterate the cavity by one of the methods

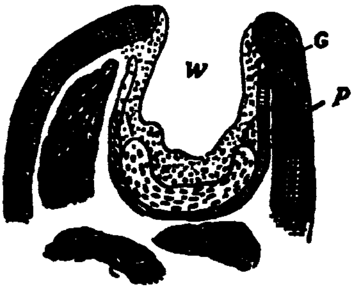


FIG. 24.—SEQUESTROTOMY (BINNIE) (2). Same as Fig. 23 with removal of sequestrum and involucrum.

described later. One method is to level the sides of the cavity (Figs. 23, 24, 25) so as to leave a wide and shallow depression in the bone, instead of a deep narrow cavity. This will allow the periosteum and soft parts to fall over and adhere to the raw surface (Fig. 25). Another method (Fig. 26) is to remove one entire side of the involucrum lining the cavity (leaving the periosteum), the whole of the other side or wall being retained, which will allow the periosteum and soft parts to fall in and obliterate the cavity. After removing the dead and infected portions of bone, there may be a mere splint of sound bone left maintaining continuity. This is quite sufficient, as it will thicken and grow rapidly. Avoid fracturing the involucrum, which remains, for upon this the continuity depends. The cavity being obliterated, the soft parts are brought together and healing by first intention is sought. If one believes that the tissues have been made aseptic and no cavities are left, the entire wound may be closed without drainage. If any cavities remain they should be drained or else filled with Mosetig-Moorhof's iodoform and wax plug. If one is in doubt about the asepsis, as will occur probably in most of the cases, the wound may be packed and if, after a few days, the wound does not suppurate, then it may be sutured. After dressings are applied, the limb is fixed in a splint.

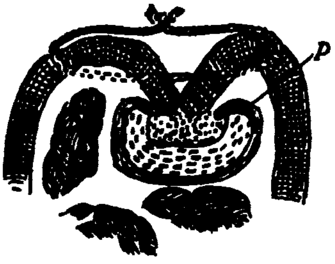


Fig. 25.—Sequestrotomy (Binnie) (3). Same as Figs. 23 and 24. Periosteum and soft parts are brought over the raw surface.

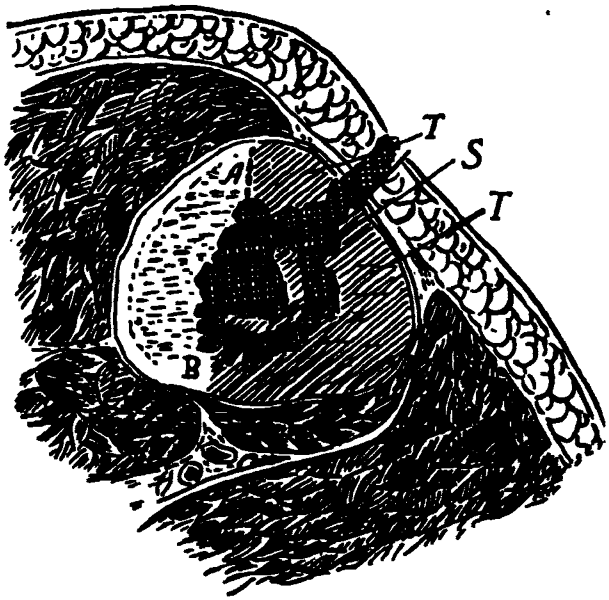


Fig. 26.—Sequestrotomy (Binnie) (4). T is the involucrum and S the sequestrum. The bone is divided at A and B and all the shaded area removed.

Methods of Obliterating a Bone Cavity After Sequestrotomy (Modified from Binnie).—1. *Mosetig-Moorhof's Iodoform and Wax Plug.*—The following prescription is prepared beforehand: Iodoform 60 parts; spermaceti 40 parts; oil of sesame 40 parts. Heat slowly to 100° C. When the mass cools, it forms a soft solid at the body temperature. Immediately before use, heat the iodoform mixture in a water bath to 60° C. to render it fluid. Pour this fluid into the bone cavity slowly so as to avoid the formation of air bubbles. Fill the bone cavity completely and allow the fluid to solidify, following which close the periosteum and soft parts with interrupted sutures, which will allow drainage to take place. Bone will eventually penetrate and replace the iodoform plug.

2. *Neuber's Iodoform Starch.*—Mix 10 grains of wheat starch with the smallest possible amount of water in an open glass vessel, pour into this, constantly stirring the mixture, 200 grains of boiling 2 per cent. watery carbolic solution. After partial cooling, stir in 10 grains of powdered iodoform. Pour into a sterile glass flask. This mixture may be kept for weeks in a dark room. It is used in the same manner as Mosetig-Moorhof's iodoform wax.

3. *Emil Beck's Bismuth Paste.*—The formula is as follows:

Bismuth Carbonate	30.0	grams
White Wax	5.0	"
Soft Paraffin	5.0	"
Vaselin	60.0	"

Mix while boiling, and avoid any spilling of water into the paste. It is used the same as the preceding.

4. *Schede's Aseptic Blood Clot.*—This has been already mentioned. The periosteum, soft parts, and skin are united by interrupted sutures, in layers, elastic constrictor is removed and enough bleeding takes place to fill the cavity with blood. Excess of blood is carried through the spaces between the interrupted sutures into the dressings. On the appearance of signs of decomposition in the wound, which is more than likely to happen, the wound must be opened, the clot evacuated and drainage provided.

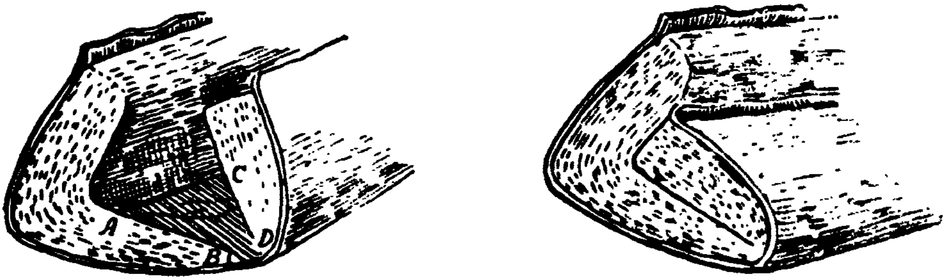


FIG. 27.—SEQUESTROTOMY (BINNIE) (5). A wedge-shaped piece of bone (avoiding the periosteum) is removed, allowing the mobilised wall to fall in and obliterate the cavity.

5. *Senn's Decalcified Bone Chips.*—The bone is cut into small pieces, decalcified and preserved in absolute alcohol until just before use, when it is immersed for some minutes in sterile salt solution. Decalcified cancellous bone is better than the compact tissue, when it can be obtained, as it forms a better supporting medium. The small fragments are packed closely together up to the level of the periosteum, which is sutured over them. The tourniquet is loosened and the cavity fills up with blood. This method is only effectual in an

aseptic wound and should not be tried in an infected one. Ultimately the whole cavity becomes filled with young tissue, which gradually organizes into fibrous tissue.

6. *The cavity remaining after removal of the sequestrum has walls which prevent obliteration by the falling in of the overlying soft parts.* With the chisel cut through the bone at the base of one of the walls for the whole length of the cavity, but carefully avoid cutting through the periosteum. Remove a wedge-shaped piece of bone (Fig. 27, A B C D) along this line of section, which will permit the mobilized wall to fall in and obliterate the cavity.

7. *Osteoplastic Method of Schultén* (14).—The anterior wall of the bone cavity is removed, sequestra extracted, and the cavity disinfected. This is packed with sterile gauze for about 3 weeks, until it is covered with healthy granulation tissue. After being packed with gauze, the wound should be partly closed with sutures to prevent too much retraction of the soft parts. Divide the lateral bony walls of the cavity transversely at both its extremities and also at its middle with a chisel. Introduce a chisel into the bone cavity through the anterior opening and remove a triangular piece of bone on each side (Fig. 28, B E D F and H I K) of the base, at the junction of the lateral walls with the base. Be careful to leave the periosteum intact. Slide the lateral walls A and B together in front of the base C, and fix them to each other with periosteal chromic gut sutures. Close the wound in the soft parts, dress, and apply a splint.

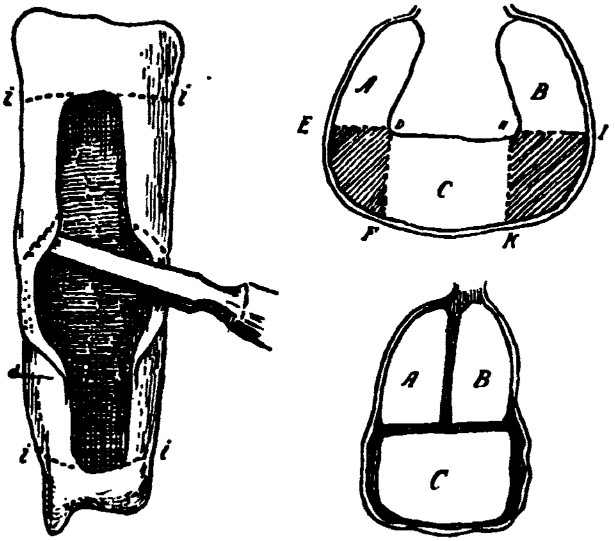


FIG. 28.—OSTEOPLASTIC METHOD OF SCHULTÉN FOR OBLITERATING A BONE CAVITY AFTER SEQUESTROTOMY. The triangles of bone E D F and H I K are removed and the lateral walls A and B are pushed in in front of C.

8. *Neuber's Method of Invagination.*—All dead bone has been removed, the cavity disinfected and all sclerosed connective tissue dissected away. With the chisel remove most of the lateral walls of the bone cavity, but preserve the periosteum. Invaginate the overlying soft parts and fix them in position by suture, pegs, nails, or strapping.

9. *Af Schultén's Procedure for Obliteration of Cavities in Lower End of Femur.*—This could be as well applied to cavities in other bones when necessary. Two or 3 weeks after the operation for sequestrotomy has been done,

the cavity is scraped free of all granulation tissue and thoroughly disinfected. At the upper and lower ends of the primary longitudinal incision add two transverse incisions, both in the same direction, which go through the skin alone. Reflect the skin and expose the deep fascia. Make the flap A B C as shown in Figure 29, 1, consisting of deep fascia, muscle, and periosteum, with its pedicle above. The flap is made on the side of the cavity and must be long enough and so located as to fall easily into the bone cavity after being mobilized (Fig. 29, 3). In mobilizing the flap it is advisable to use a chisel so that a thin shell or fragments of bone shall remain attached to the periosteum. If the shape of the upper end of the bone cavity interferes with the pedicle of the flap where it is implanted into the cavity, trim the bone with the chisel as much as is necessary. Fill the cavity with the mobilized flap and fix it with catgut sutures (Fig. 29, 3). Do not drain. Apply a splint after closing the soft parts. Apply dressings so loose as not to cause any pressure. When the bone cavity is very deep, two muscle and periosteal flaps may be used one above the other (Fig. 30), one flap coming from each side. When the bone cavity is very long, two flaps may be used (Fig. 31), one coming from above on one side and the other from below on the opposite side.

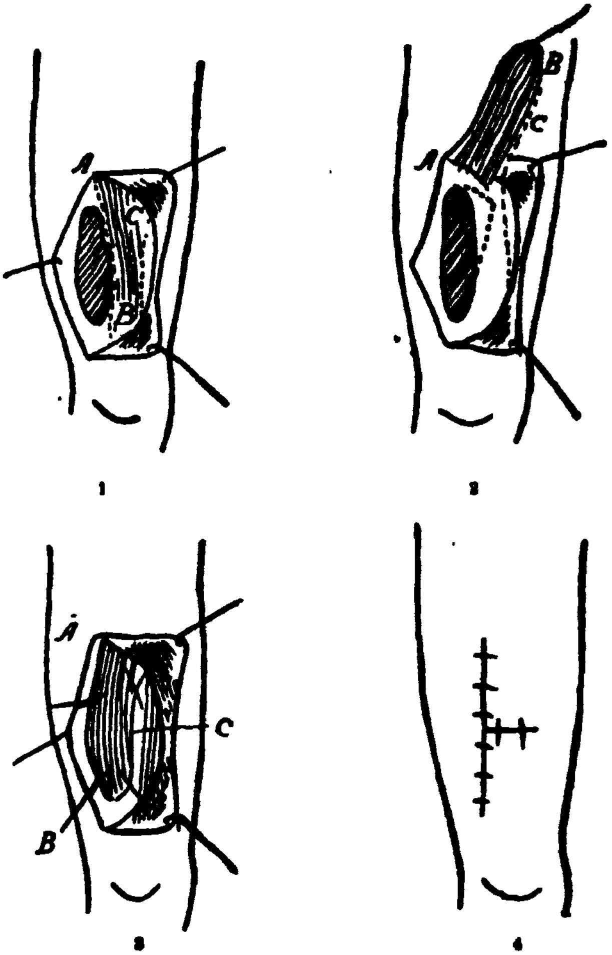


Fig. 29.—Flap Method of Obliterating Cavities of Af Schultén. A B C, flap of deep fascia, muscle and periosteum. 29, 2, flap A B C lifted up. 29, 3, flap A B C filling the cavity.

10. *Treatment of Large Defects in Tibia: Von Eiselsberg's Method* (Figs. 32, 33).—Von Eiselsberg adapted the König-Muller method of closing cranial defects to the treatment of large defects in the tibia. While the method was devised to repair the damage done by the removal of a sarcoma, it may be em-

ployed to rectify defects from other causes, such as total necrosis of a long segment of the tibia. Apply an elastic constrictor. Clean and vivify the defect, particularly the ends of the stumps of bone. If very little of the lower end of the tibia remains it may be removed and a portion of the astragalus vivified for the reception of the flap. Divide the skin so as to make the flap A B C as shown in Fig. 32, and carry the incision through the periosteum. Lift the edges of the periosteum from the bone beneath for about ⅛ in. With a chisel cut into the medullary cavity through the whole thickness of the cortical bone along the dotted line shown in Fig. 32. Do not separate the overlying soft parts from the segment of bone. Lift this segment up. This gives a flap consisting of skin, periosteum and cortical bone provided with the pedicle at A. Twist the flap into position to fill the tibial defect (Fig. 33) and suture it in place. Do not apply too much torsion to the pedicle nor have any degree of pressure on the pedicle or flap. Close the wound left in the upper part of the leg by undermining the skin edges and sliding them over the osseous wound. If complete closure is not possible, apply Thiersch's skin grafts either at once or subsequently. Apply dressings and a splint.

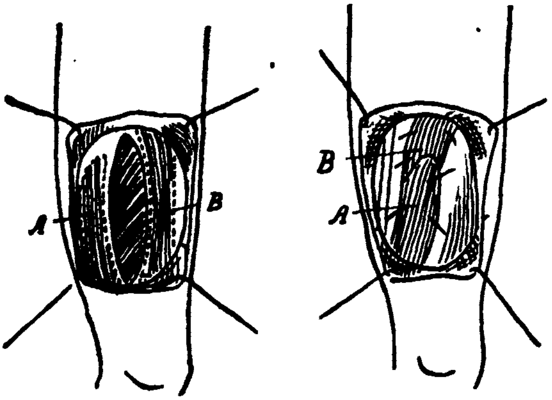


FIG. 30.—TWO MUSCLE AND PERIOSTEAL FLAPS A AND B One coming from each side, one above the other; one flap superimposed on the other obliterating the cavity.

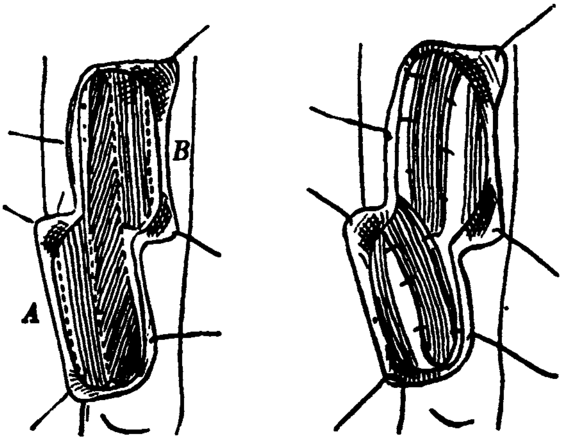


FIG. 31.—TWO FLAPS A AND B FASHIONED SIMILAR TO THOSE IN FIGURE 30. One coming from above on one side and the other from below on the opposite side. Flaps A and B mobilised and reflected obliterating the cavity.

Huntington's Operation.—This procedure was devised to supply an extensive loss of the whole thickness of the tibia by making use of the fibula. The field of operation must be aseptic. For a description of this operation, see Bone Grafting, page 500.

11. *Free bone grafts* may be used very successfully to fill up cavities in bone.

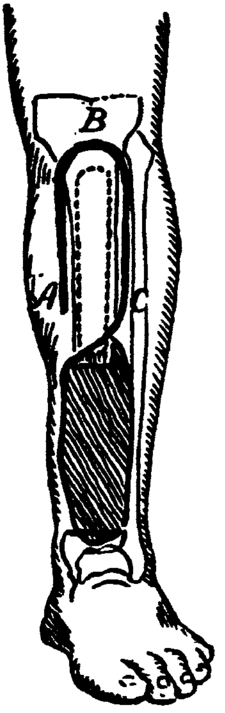


FIG. 32.—VON EISELSBERG'S METHOD OF TREATMENT OF LARGE DEFECTS IN TIBIA.

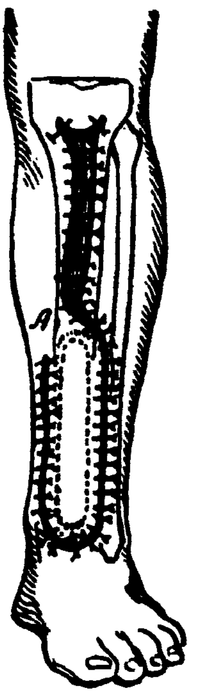


FIG. 33. VON EISELSBERG'S METHOD COMPLETED.

The grafts must have periosteum on at least one side, and the cavity must be aseptic (for methods, see Bone Grafting). When the whole thickness of the shaft of a bone has been removed, it is replaced, as a rule, by new bone from the surrounding periosteum. If both bone and periosteum be removed for any considerable distance between the ends of the bone, including its whole thickness, there will not be sufficient formation of new bone to bridge the defect. Hence the value of preserving the periosteum. If but a portion of the shaft be removed, then new bone is formed from both the old living bone and the periosteum. If the whole shaft be gone but the periosteum preserved, the growth of new bone is slow and may take a year for its completion. Therefore, as long as radiograms show that new bone is actually being formed, there is no need of interference. If the growth stop, before complete repair of the shaft, the gap may be bridged by grafting in a piece of bone taken from the same patient.

TUBERCULOSIS OF BONE

It is not necessary to describe the treatment of tuberculous deposits, tuberculous osteomyelitis, and tuberculous periostitis separately. It will suffice to take up the three clinical divisions:

1. Tuberculous disease of bone without abscess.
2. Tuberculous disease of bone with unopened cold abscess.
3. Tuberculous disease of bone with septic sinuses.

1. Tuberculous Disease of Bone without Abscess.—The greatest difficulty is in the diagnosis. Radiography is often of great value. In certain cases, such as dactylitis, there need be but little difficulty, since the only other possibility is syphilitic disease. The bone enlarges with but little pain. Tumors of bone must be excluded.

Palliative measures, as for tuberculosis in general, should be early and carefully instituted and will do immense good. In tuberculous dactylitis many cases recover under palliative means without operation, if no abscess has formed.

RADICAL MEASURES.—If the tuberculous deposit be in the articular end of the bone, it has a great tendency to open into the joint, thus infecting it. To anticipate and prevent this should be our aim, hence a radiogram should be taken, which will decide as to whether such a deposit be present or not. If present, it should be opened at once. If there is a tender spot, it should be cut down upon, because at that point the deposit will be nearest the skin. The incision should be so planned as not to open the joint and to expose the bone where the thickening is most marked. The periosteum is incised and peeled back. The surface of the bone is removed. If a caseous deposit be present, unduly soft bone is soon encountered; if there be a sequestrum, the bone will be externally dense. In the case of a soft deposit all the tuberculous material should be removed until a cavity with fairly firm walls is left, and then a thin layer of this denser bone should be removed. Microscopic examination shows that the disease seldom extends more than ⅛ in. into the bone beyond the soft deposit. If there be a sequestrum, it must be removed. Sequestra are very slow in separating, hence cannot be lifted out as those due to acute osteomyelitis, but must be torn out with forceps. The walls of the cavity must then be removed in a thin layer. If the whole of the tuberculous material has been removed, the wound may be closed without drainage. If there be doubt about the removal of all the tuberculous material, the cavity should be swabbed out with pure carbolic acid and alcohol, followed by tincture of iodin, and then packed. This packing is continued until the cavity completely fills up with granulations.

In tuberculosis of the small bones, as those of the tarsus, it is often best to excise the entire bone in the early stage without attempting merely to remove the deposit. The removal of one of the cuneiforms, for instance, does not in any way cripple the patient and gives an excellent result, besides cutting short the disease and preventing its spread to the joints.

2. Tuberculosis of Bone with Unopened Cold Abscess.—Cold abscesses may originate either from tuberculous periostitis or from the interior of the bone. When possible, the abscess should be excised, together with the periosteum and the bone, as if it were a cyst. A good example is tuberculosis of a rib. A free incision is made over the abscess in the line of the rib and the soft parts separated from the abscess wall, which is then well defined. The rib is exposed beyond the limits of the abscess and cut across by pliers on each side, so that the abscess and bone are removed in one mass. Tuberculous material will usually be found behind the rib, lying on the posterior periosteum. This should be scraped and disinfected without injury to the pleura. The wound may frequently be sewn up without drainage. When this treatment can be adopted in other bones it should be used. In tuberculous dactylitis with abscess similar treatment should be given. Do not amputate. After removal of the diseased bone, when the wound has completely healed, the defect in the bone can be made up by the insertion of a bone graft.

When the abscess is very large and cannot be dissected out, it should be freely opened, its walls removed, and the diseased bone exposed and extirpated.

After this the wound can usually be completely closed. In cold abscesses of deep-seated bones, such as the spine or pelvis, the abscess should be aspirated (not opened) and injected with iodoform and glycerin emulsion.

3. **Tuberculosis of Bone with Septic Sinuses.** The skin should be carefully disinfected and the granulations at the orifices of the sinuses should be scraped away. The skin about the sinuses should be coated with vaselin and a small gauze sponge wet with pure carbolic acid inserted into the sinus. This should be left in situ and a probe passed by it into the bottom of the sinus. Two circumscribing incisions should be made about the sinus and the tissues divided in the direction indicated by the probe, the sinus being included in the dissection. The healthy bone on all sides of the sinus should be exposed and chiseled through so that all the diseased tissues are removed in one piece.

Many cases of septic sinuses are not suitable for this thorough treatment, and such cases must be treated by local applications. The best is apparently the injection of Beck's bismuth paste.

ACTINOMYCOSIS

This disease is due to a fungus called the actinomyces, which is common in cattle. It may affect either the soft tissues or the bones, and it has three main seats, the mouth and its neighborhood, particularly the jaws, the respiratory and the abdominal organs. The bone most frequently attacked is the lower jaw. The disease usually begins as a hard tumor about the angle, gradually increasing in size until suppuration occurs and an abscess forms and bursts, either externally or internally, into the mouth. The bone becomes progressively destroyed and numerous sinuses form, the discharge containing yellow granules. The disease when once established in the bone may lead to metastatic deposits in the glands or in other bones. There is usually no fever attending the disease, which varies very much in its virulence, some cases being quite mild, while others are almost beyond successful treatment.

Treatment.—As soon as the disease becomes evident, the affected area of bone should be cut down upon and, if only a small portion be diseased, this should be completely excised. If it be too extensive for this, the swelling must be thoroughly opened and scraped away so as to remove as much of the disease as possible. This is to be followed by the application of pure carbolic acid followed by alcohol. Potassium iodid in large doses should be administered. Very satisfactory results are obtained in this way.

TUBERCULOSIS OF THE SACRO-ILIAC SYNCHONDROSIS

This disease may be primary or it may be secondary to disease of the lower lumbar vertebræ or combined with lumbosacral disease. When it begins p marily in connection with the joint it generally takes the form of a deposit in the sacrum or ilium, usually in the former; as these deposits enlarge they invade the articulation. The interosseous ligament is usually only partially destroyed.

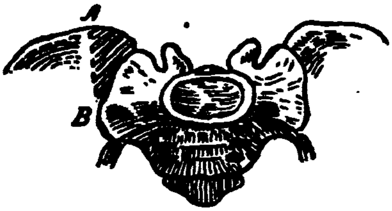


Fig. 34.—Exposure of Sacro-iliac Joint. A portion of the ilium must be removed, A B.

Treatment.—The first essential is rest in the recumbent position between sand-bags, or, better, in some arrangement like Phelp's box. No satisfactory apparatus has been constructed to allow the patient to get about.

OPERATIVE TREATMENT.—Picqué's method (13) is as follows: A long curved incision is made posteriorly, with the convexity running along the middle of the sacrum, going well above the crest of the ilium and downward over the sacrosciatic notch. The flap of skin and fascia and the glutei muscles are turned outward. With a periosteal elevator reflect the periosteum (which is still attached to the soft parts) from the ilium outward. To reach the sacro-iliac joint a portion of the ilium must be removed (Fig. 34, A B). The incision of the segment of bone may be partial or complete.

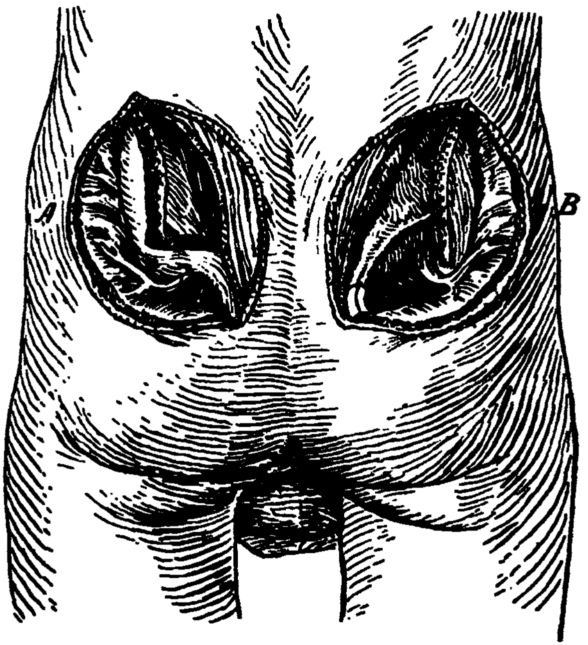


Fig. 35.—Excision of the Ilium. A, partial excision of segment of ilium; B, complete excision down to the outer and upper corner of the great sciatic notch.

For *complete* excision, with an osteotome divide the iliac bone vertically from the crest down to the outer and upper corner of the great sciatic notch (Fig. 35, B).

For *partial* excision make the vertical incision shorter and supplement it by a transverse one (Fig. 35, A), in such a fashion as to leave the sciatic notch intact.

Having divided the ilium, pry up the fragment of bone with an elevator, divide its ligamentous attachments and remove it. This excises the iliac portion of the sacro-iliac joint and freely exposes the articular and adjacent portions of the sacrum. With scoop, rongeur forceps, and chisel remove all disease from the sacrum. When the sacral foramina are involved, expose and isolate carefully the nerve trunks so that they be not injured, then excise as much bone as necessary, which will vary with the extent of the disease. In one case, Piequé writes, the wound will have a bony floor formed by the anterior portion of the wing of the sacrum, united to the ilium by the anterior sacro-iliac ligament; in another case the wound will penetrate the pelvis, exposing the sacral nerve trunks, the iliac vessels, and the ureter. Thus the resection of the sacrum, like that of the ilium, will be partial or complete. Piequé sutures part of the wound and packs the remainder with gauze. He says that frequent curetings will be necessary. It appears to me that packing should be used only in cases secondarily infected. Where packings are used, the subsequent sinus should be injected with Beck's paste. When there is no secondary infection the wound should be closed without drainage, the cavity being first filled with Mosetig's iodoform wax plug.

SYPHILITIC OSTEOMYELITIS AND PERIOSTITIS

The lesions produced by syphilis of the bones are often so characteristic as to be recognizable at a glance. In other cases they are not so easy to diagnose. Syphilis may affect the central marrow, the marrow of the cortex, or the periosteum. Sometimes all three suffer.

Early in the disease there are bone pains which are probably due to congestion. Under treatment these soon disappear and leave no trace. From the sixth month onward a definite syphilitic periostitis occurs which may lead to the formation of bony nodes. This happens most frequently in the frontal bone, ribs, sternum, tibia, and clavicle. The periosteum is thickened, and beneath it there is an effusion of gelatinous material, in which ossification may take place, forming a syphilitic node. Prompt treatment will dispel this periosteal thickening, but not the bony nodes. In the tertiary stage gummata may occur subperiosteally or in the medulla, and there may be either a circumscribed gummatous mass or a diffuse infiltration of the whole bone. The circumscribed gummata are most frequent on the skull, where they may begin either under the periosteum or in the diploë, also in the vomer, nasal bones, palate, clavicle, tibia, and the epiphyseal ends of other bones. The gummatous material extends from the deeper layer of the periosteum into and along the Haversian canals, and produces a rarefying osteitis in its neighborhood. Beyond this area condensation of the bone occurs so that the bone presents an eroded and worm-eaten surface, due to the great size of the Haversian canals, with very dense bone around. This condition is called syphilitic caries and great destruction of bone may result from it. Syphilitic sequestra may be formed. When gummata occur in superficial bones they spread into the soft tissues and involve the skin, which gives way, forming a syphilitic ulcer, at the bottom of which there is bare bone, soft on the surface, but very dense beneath, so that a probe cannot be pushed into it for any distance. What gives to syphilitic disease of the shafts its peculiar, almost diagnostic, appearance is the thickening of the periosteum, a production of new bone, sometimes spindle-shaped and sometimes more diffuse, and extending for a considerable distance. Especially in congenital syphilis, the tibiæ become much thickened and curved anteriorly, taking on a peculiar "sabre shape." Congenital syphilis is also responsible for the fairly frequent disease of the metacarpals and phalanges, and a condition results which is with difficulty distinguished from tuberculous dactylitis. Secondary infection and sinus formation are fairly frequent in syphilitic dactylitis, and a portion of the end of one or more of the finger bones may be destroyed. The Wassermann reaction will usually be present.

Treatment.—Tertiary bone syphilis is very rebellious to internal antisyphilitic remedies alone, particularly when there is an external ulcer. Surgical intervention may materially shorten the course of the case, although our main reliance must be in mercury, salvarsan, and the iodids. If improvements under these drugs be not prompt, an operation should be done, which consists in opening up the affected area, scraping away the diseased tissue, chiseling away some of the dense bone, and removing any sequestrum. The cavity is disinfected and packed and allowed to heal from the bottom.

GONOCOCCIC INFLAMMATION OF BONE

Gonococcic osteomyelitis is rare, although not unknown. Gonorrheal periostitis is fairly frequent in certain localities, especially under the calcaneus, in which situation spurs result from the inflammation. These bony spurs should be chiseled away. A peculiar condition of sensitive feet, found occasionally in patients with chronic gonorrhea, is probably due to a mild degree of periostitis. The patients walk as if they were treading on eggs. The affection yields to strapping and to treatment of the urethra.

TYPHOID OSTEOMYELITIS AND PERIOSTITIS

Typhoid osteomyelitis and periostitis are fairly frequent. The typhoid bacillus alone may be the causal organism or it may be complicated by ordinary pus cocci. Abscess formation is frequent and the bone is killed in greater or smaller pieces. Fistulæ remain open for a long time. Where there is no complicating secondary pus infection the treatment may be conservative. Vaccination may be sufficient. If secondary infection occur, incision, removal of infected bone and sequestra, disinfection of the cavity followed by packing are all in order. The case should be treated like simple osteomyelitis.

RHEUMATIC PERIOSTITIS AND OSTEITIS

Rheumatic periostitis and osteitis may occur as the result of rheumatism, and are probably caused by the same organism which causes the joint lesion. A periostitis may be produced with a condensing osteitis beneath, or the whole thickness of the bone may be involved. The main difficulty is in making a diagnosis as to the infecting organism. In mild cases the limb should be put on a splint and blisters applied. Salicylate of soda or iodid of potassium should be administered internally. If the disease is not bettered by this treatment and the pain is severe, the best plan is to cut down and remove as much of the thickened periosteum as possible, at the same time chiseling away all or a part of the thickened bone: in these cases it is scarcely necessary to open up the medullary cavity. There are cases of so-called "neuralgic osteitis" in which the pain is intense. This is probably due to pressure on the nerves in the thickened bone with a resulting neuritis. Free chiseling away of the affected portion is the only treatment that affords any relief. Marked improvement often results.

OSTEITIS DEFORMANS

(*Paget's Disease*)

The exact pathological process at the bottom of this disease, as well as the etiology, is still a matter of debate. Probably one will not go far wrong in considering it as a chronic osteomyelitis due to some obscure infection. In the early stages there is a diffuse fibrous osteomyelitis with the formation of multiple small cysts, with later on the formation of new bone which runs diffusely through the affected and the adjacent healthy portions. The bone becomes exceedingly thickened and asymmetrical, but since the new bone tissue remains uncalcified, its elasticity permits of great deformity of the long bones from the weight of the body. Fractures, which are so frequent in osteomalacia, do not occur in Paget's disease. In osteomalacia there is no production of new bone at the periphery as in Paget's disease. The disease usually occurs after the age of 45 and preponderates in the male sex. Ely gives the manifestations of the disease as follows:

> "The legs and thighs are bowed outward, the former almost forward. The lower extremities, as a whole, seem too large for the trunk. The spine possesses a long stiff anterior curvature, not unlike that of an ordinary spinal arthritis. The skull is enlarged, the head carried forward, and the hips widened. The bones of the arm and forearm may be affected, but not so severely nor so early as are the bones of the lower extremity. The skull and the tibiæ are usually the first bones to show the morbid changes. The disease usually progresses steadily, the muscles become weak so that walking is difficult and the patient ultimately dies of exhaustion, or of some intercurrent disease, or, as has occurred in a certain proportion of cases, of malignant bone tumors."

Treatment is palliative and unsatisfactory. Antisyphilitic drugs may be tried. Braces may be used to support the lower extremities. Ely suggests careful search for some source of infection.

FRAGILITAS OSSIUM

Bone fragility occurs in a number of different diseases, particularly in malignant growths, senile atrophy of bone, osteomalacia, and tabes. The so-called idiopathic fragilitas ossium (*osteopsathyrosis idiopathica*) is a rare congenital condition in early life in which the bones are imperfectly ossified. They are so brittle that multiple fractures occur, particularly of the long bones. In many instances fractures occur in intra-uterine life and are often multiple. A similar condition, due to simple atrophy of the bone, occurs in extreme old age.

The fractures occur from the least possible force; almost spontaneously. If a young patient should chance to reach adult life, the condition disappears, the fractures heal, often with vicious union, and the patient is stunted. The only known treatment is to protect the child from injury so as to prevent the occurrence of fractures. A Wassermann reaction should be taken to rule out congenital syphilis.

OSTEOMALACIA

The chief manifestation of this disease consists in softening of the bones, which affects the whole skeleton and leads to excessive deformity. It occurs in adults, particularly in pregnant women and those in whom pregnancies are rapid and repeated. Women are affected nine times more frequently than men. Spontaneous fractures are frequent, and, on account of the softening, the bones bend in a most extraordinary manner. In the late periods of the disease nothing but the periosteum may remain, and this is filled with broken-down material. The disease is slow but usually proves fatal, in about 2 years after its commencement, from cachexia, asphyxia, or some acute pulmonary disease. Treatment is usually without avail. If the patient is pregnant, abortion should be performed and future pregnancies should not be permitted. Improvement has been recently reported from the use of tabloids of bone marrow. The patient should be put under the best hygienic conditions. Preparations of phosphorus may be tried. In some instances recovery has followed the removal of the tubes and ovaries. It has now been shown quite definitely that it is not the removal of the ovaries, but the effects of the chloroform anesthesia which brings about the cure. These patients should therefore be anesthetized once for one-half or three-quarters of an hour with chloroform, which may produce a cure (Mayo).

ACROMEGALY

For consideration of this disease, see Surgery of the Nervous System (Surgery of the Hypophysis).

RICKETS—RACHITIS

The changes in the bones only will interest us here, but it must not be forgotten that these bone changes are only part of a general constitutional disease.

They manifest themselves as enlargements about the epiphyseal lines and as curvatures of the bones, producing deformities. Fractures also may occur. The deformities produced requiring treatment are as follows: coxa vara, coxa valga, curved femur, curved tibia, genu valgum, and varum and genu recurvatum. For the operative treatment of these deformities, see Osteotomy.

The general constitutional treatment of rickets is all-important, and may be found in any good text-book on pediatrics.

The main surgical point to be considered in rickets is the treatment of the deformities of the limbs, which are so liable to occur. While the disease is progressing the child should not walk nor run about, but should be confined to a mattress, the object being to prevent the deformities from taking place in the lower limbs and pelvis. The child should be taken out into the sunshine as much as possible. When the deformity of the limbs is still slight the chances are good that the child will outgrow it, provided standing or walking can be prevented. Manipulations of the deformity should be practiced in such a way as to unbend the curve, and it is surprising how much can be done to overcome the deformity by this means. The limb should be grasped at the extremities of the curve, the thumbs applied opposite the point of greatest convexity, and the bone straightened by steady and gradual pressure, which does not cause the child pain. In the more advanced cases, when there is distinct bending of the bones, which are still soft, braces or splints, combined with massage, electricity, and manipulative measures to reduce the curve, are in order. For the leg a straight internal splint of wood, carefully padded opposite the tuberosity of the tibia and the internal malleolus, extending from the middle of the femur to 6 inches beyond the sole, is applied. When the splint projects less than this beyond the sole it is possible for the child to walk on the points of the toes, which should not be allowed. This splint is firmly fixed above and below with straps and buckles, and a broad piece of elastic webbing may be applied opposite the point of greatest convexity, so as to draw the limb gently laterally against the splint. Rotation may be prevented by having a light iron bar screwed to the lower end of the splint and fastened to the heel of the boot. Care should be taken not to apply sufficient force to produce ulceration of the skin. The main object of the splint is to prevent the deformity from becoming worse, since, unless the bones are so soft that they can be straightened by hand, the application of splints can produce little alteration.

For the severe deformities, when solidification has taken place (usually at about 4 years of age), nothing but operation can be considered. Operation should never be done, however, while the bones are still soft. For operative treatment, see Osteotomy.

SCURVY

Scurvy both in infants and in adults is due primarily to a lack of fresh animal and vegetable food. In infants it may be combined with rickets. Whereas in adults spongy, bleeding gums are the most frequent signs of scurvy, in infants the disease usually manifests itself by subperiosteal hemorrhages in the long bones. The femur is most frequently affected and the bones of the lower extremity are usually attacked before those of the upper. At some points along the course of the bone a firm swelling appears, due to blood effused beneath the periosteum. As a rule, fluctuation is difficult to make out. Fractures are apt to occur in bones thus affected, either spontaneously or following slight violence, and union does not take place until the disease has been arrested. In cases of scurvy pure and simple, these fractures are commonest in the shafts of the long bones; while in scurvy associated with rickets, separation of one or both epiphyses of the affected bone is more likely to be met with. Intense pain, when the affected bones are handled, is characteristic. This may be the first symptom noticeable, the child crying out when he is handled or washed.

Treatment.—For the general constitutional treatment, which is all-important, any good text-book on internal medicine may be consulted. Only the surgical treatment will concern us here. In severe cases rest in bed should be enjoined, on account of the liability to fractures. A splint should be applied to the affected extremity, particularly if a fracture has occurred. Rest will likewise favor the absorption of the subperiosteal extravasation, which will take place as the disease yields to constitutional treatment. Should there be fever and much persistent tenderness, not yielding to the constitutional treatment, then suppuration may be suspected. The only way to clear up the doubt of its presence is by the use of a large aspirating needle. Should pus be evacuated, then the periosteum should be split and the abscess drained. Should the extravasation be very large, absorption is sure to be slow, and it may come to a standstill at any time. In such a case it may be advisable to cut down upon the swelling, incise the periosteum, and turn out all the clot, which is removed partly by the finger, partly by gentle irrigation with normal salt solution, partly by gentle use of a spoon, and by compressing the limb. The wound is then sewn up without drainage and a smooth dressing of cotton applied, which is bandaged firmly so as to exert compression, which prevents re-accumulation of blood. Such treatment hastens absorption and lessens adhesions between muscles. The strictest antiseptic precautions must be followed, as infection would cause widespread necrosis of bone to ensue.

OSTEITIS FIBROSA AND BENIGN BONE CYSTS

Osteitis fibrosa is the result of a low-grade mild inflammatory affection of the bone and medullary tissues, in which destruction of bone takes place. Regeneration only goes so far as to replace the bony and medullary structures with granulation tissue. In osteitis fibrosa this granulation tissue is converted into connective tissue, with or without the formation of bone cysts. The cysts may be single, but are not infrequently multiple. None of the long bones seems to be exempt from invasion by this inflammation, the upper extremity of the humerus being particularly prone to develop the process, as well as the femur and tibia.

The great majority of cases begin before 20 years of age, and the bone, if a cyst be present, increases in size slowly as compared with one that is the seat of a malignant tumor. Fracture of the affected bone at the site of the cyst, due to the thinning of the bony walls, is very frequent, and this may be the first objective evidence of the disease.

Treatment.—The treatment of osteitis fibrosa without cysts is the removal of the fibrous tissue. The striation and size of the area involved is easily determined by a radiogram. The periosteum, usually normal, is incised over the affected area and a gutter is chiseled through the thinnest compact tissue and the whole of the fibrous tissue is carefully scraped away. The cavity is either filled with normal salt solution (Sherman), or with bismuth paste, or is allowed to fill with blood. The periosteum is sewn together over the cavity, and the wound closed without drainage. Splints should be applied to prevent fracture. If a fracture has already occurred, the same treatment as for simple fracture should be adopted.

If cysts be present, the shaft of the bone is often greatly expanded, the bone in the walls being only tissue-paper thin. In cases in which the cyst cavity does not involve a great extent of the shaft, the cyst should be opened and thoroughly curetted. The periosteum is closed over the cavity, which is filled either with salt solution or bismuth paste, or allowed to fill with blood. In large cysts so much of the shaft may be involved and its walls may be so thin that even curetting may practically amount to excision of a portion of the shaft. If this be the case, then the periosteum should be stripped off the whole extent of the cyst, and the whole of the thin wall of the latter removed. Shortening must be prevented by the insertion into the medullary cavities of the upper and lower fragments of a bone graft with periosteum, taken preferably from the patient's own tibia. The reflected periosteum is sewn around the bone graft and the wound closed. Splints should be applied. (See Chapter on Bone Grafting.)

BLASTOMYCOSIS OF BONE OR COCCIDIOIDAL GRANULOMA

This is a disease caused by a fungus called oïdium coccidiodes, whose localization in bone is rare. It causes in the bone marrow an infectious granuloma, with endothelial hyperplasia and with breaking down of tissue and the formation of cold abscess with sinuses. The disease in the bone is usually diagnosed as tuberculosis, and a correct diagnosis is only made by finding in the pus large, doubly refracting yeast bodies. Brewer reports a unique case of blastomycosis of the vertebræ, with two separate foci in the spine and laminæ of the third dorsal vertebra, and in two of the upper lumbar spines. Two operations were done, and the man has remained well. The prognosis of blastomycosis of bone is bad. The only hope lies in attempts at extirpating the foci by operation and sterilizing the cavity resulting therefrom by applying pure carbolic acid to the interior of this cavity.

TUMORS OF BONE

Tumors of bone are either primary or secondary. The primary tumors are chiefly exostoses, chondromata, and sarcomata.

Secondary tumors are sarcomata and carcinomata and arise either by metastases or by extension from neighboring parts. Hydatid cysts also occur.

EXOSTOSES

(*Osteomata*)

Exostoses occur in two forms: 1. The *ivory sessile variety* is found chiefly on the skull, and usually do not grow to any great size. As a widespread fissured fracture of the skull may be produced by attempting to chisel them away, they are better left alone, unless some special indication, such as pressure, presents. In their removal the best plan is to encircle the area of tumor with a motor circular saw, keeping just outside the limits of the growth so as to avoid cutting through the dense bone. 2. The *spongy pedunculated exostoses,* which may be single or multiple, occur in the neighborhood of the epiphyseal lines and they may interfere with the movements of the joints. They frequently have a very narrow neck. An incision is made down to the tumor whose neck is cleared and chiseled through. The growth is then shelled out of its capsule.

CHONDROMATA

Chondromata are commonly found in the phalanges and metatarsal or metacarpal bones, occasionally on the extremities of the long bones. They are usually multiple and grow either from the outside or in the interior of the bone. One should cut down upon the tumor and chisel it away at its base, this to be followed by gouging away any deposits of cartilage left in the base of the tumor. If the tumor is growing in the interior of the bone, the outer layers must be chiseled through and then the soft cartilaginous material scooped away. Sometimes recurrences take place, in which case the operation may be repeated.

BENIGN MYELOMA

Medullary Giant Cell Sarcoma, Myelogenous Giant Cell Sarcoma, Medullary Giant Cell Tumor—Bloodgood

Benign myeloma of bone was, until quite recently, regarded as a variety of sarcoma. It is now considered by modern authorities as a benign growth, with a tendency to local recurrence, if not thoroughly removed, but without any other attributes of malignancy. Barrie has maintained that it is a chronic (non-suppurative) hemorrhagic osteomyelitis, producing granuloma. The favorite site of the growth is the metaphysis of the long bones, especially at the upper end of the tibia, and at the lower end of the femur, the radius, or the ulna. "Egg-shell crackling" is frequent over the tumor. The diagnosis may be impossible before operation. It may be difficult to absolutely distinguish a myeloma from a simple bone cyst by a radiogram. At the operation the appearance is usually characteristic. As to this Bloodgood says as follows:

> "It differs from the periosteal and medullary sarcomata of the spindle, round or mixed-cell type, by the color. It is distinctly vascular and resembles to a certain extent young granulation tissue. The appearance can be well described as that of currant jelly. Mixed with the red areas, there may be white areas, and areas mottled, white and red. The second characteristic is the consistency of the tumor. There seems to be a complete absence of any supporting stroma. It can be broken up with the finger or curet into small pieces, and one sees not even the finest connective tissue holding the pieces together, yet it does not break up into finely granular masses, characteristic of the very cellular round-cell sarcoma. The consistency resembles 'Schmierkase.' The giant cell sarcoma can be removed from its bony shell as easily as the connective tissue lining of a bone cyst."

In time the tumor extends beyond the bone and invades the soft parts, and it must then be considered distinctly malignant. If at the time of the operation there is any doubt as to the character of the tumor, a frozen section should be made on the spot. The extent of the operation will depend on the findings, whether there be large numbers of giant cells, a benign tumor, or whether it be a spindle or round-celled malignant sarcoma.

As for the treatment of benign myeloma, Bloodgood says:

> "The tumor has been permanently cured by simple cureting. Recurrences have followed cureting, but were permanently eradicated by a second operation of cureting, resection or amputation. Of over one hundred cases of the pure tumor none has given metastases. It seems justifiable, therefore, at the first operation to attempt the most conservative method, even with the risk of a local recurrence, which, if it does occur, apparently is not associated with any danger of metastases. One should not attempt cureting unless there is a thick shell of bone, so that the curet or chisel removes a zone of bone beyond the tumor. When the shell of bone is thin, subperiosteal resection should be performed; when the periosteum and surrounding muscles become infiltrated, total resection is indicated. For the periosteal giant cell tumor, local resection with chiseling of a zone of bone beneath is sufficient."

When a resection of the entire diameter of a bone has been performed it will be advisable to fill the gap with a bone graft with periosteum taken from the same patient; for example, where the whole lower extremity of the radius has to be removed, together with its articular surface, the defect can be nicely filled in with the upper portion of the fibula (with periosteum), whose articular surface is approximated to the carpal bones (see Bone Grafting).

SARCOMA OF BONE

These tumors, whether round or spindle-celled or angiosarcomatous, are very malignant. Whether central in origin or subperiosteal, they early extend beyond the limits of the affected bone and infiltrate the muscles and tendons attached to them. The muscles act as a medium for the conduction of neoplastic tissue from one bone to another, as the deltoid may become infiltrated from a sarcoma of the humerus and conduct the disease to the scapula. Despite all treatment, metastases are common, and the prognosis is bad as to ultimate cure. Binnie says as to the treatment:

> "A classical rule in the treatment of sarcoma of bone was to amputate at or above the joint proximal to the disease, that is, to remove the whole of the affected bone. This treatment ought to be effective if the tumor is still confined within the bone; if, however, muscular infiltration has taken place, even if it be not apparent to the naked eye, then the only hope of benefit lies in more extensive work. Theoretically to achieve the best permanent results one should remove the bone primarily diseased, the muscles inserted into it and the bones from which these muscles arise. This theoretical aim is nearly attained in the case of tumors of the humerus by interscapulothoracic amputation. The same principle may be easily carried out in sarcomata of the foot by amputating above the knee. Unfortunately, in many or most instances, practical considerations (primary danger, unendurable deformity, etc.) prevent the attainment of the ideal. Under these circumstances, one may amputate as high as possible and at the same time remove as thoroughly as possible the muscles inserted into the diseased bone, especially those most likely to be involved. For example, periosteal sarcoma on the outer head of the tibia. Amputation above the knee is necessary. It is probable that any neoplastic invasion of the tendo patellæ will be slow to spread beyond the patella; hence, if the disease is tolerably recent the quadriceps extensor may be considered reasonably safe. The biceps is the muscle most probably involved, hence as soon as the amputation is completed and the main vessels ligated, it would seem best to expose this muscle throughout its whole length and to excise it completely."

OSTEOTOMY[1]

The methods of performing osteotomy are three in number:

1. Linear osteotomy, in which a single clean cut is made into or through a bone.
2. Cuneiform osteotomy, in which a wedge-shaped portion of bone is removed.
3. Subcutaneous osteotomy by means of a saw.

Osteotomy upon the Femur

For Coxa Vara.—This is characterized by elevation of the great trochanter and marked outward rotation of the limb, so that in slight cases the patella cannot be rotated inward beyond the midline and, in pronounced cases, not only looks outward, but even backward and outward. The result is limping from the shortening with the foot turned out. As the disease progresses there is with outward rotation more and more adduction, until, if bilateral, a scissor-legged deformity is set up.

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[1] The author desires to acknowledge his indebtedness to Binnie's "Operative Surgery" for much that follows regarding osteotomy.

Treatment consists of rest in bed with extension, abduction, and internal rotation for all young subjects. Later the patient may get about on a Thomas's splint.

Two operative procedures may be performed.

1. **CUNEIFORM OSTEOTOMY AT THE LEVEL OF THE LESSER TROCHANTER.**—This is advised by Whitman in young children with coxa vara. He says:

> "In childhood the neck of the femur is short and the strain to which it is likely to be subjected slight, thus operative treatment may be indicated as a prophylactic measure, while in adolescence operative treatment may be deferred until the progression of the deformity has ceased. All restriction of abduction of ligamentous or muscular origin must be overcome by vigorous manipulation before the operation on the bone, otherwise it will be difficult to bring the two fragments into proper apposition. The base of the wedge should be about three-quarters of an inch in breadth, directly opposite the trochanter minor; the upper section should be practically at a right angle with the shaft, the lower being more oblique. The cortical substance on the inner aspect of the bone should not be divided, but, reinforced by the cartilaginous trochanter minor, should serve as a hinge on which the shaft of the femur is gently forced outward, until the opening is closed by the apposition of the fragments. The upper segment is fixed by contact with the margin of the acetabulum, thus preserving the continuity of the bone. The leg is then held in the attitude of extreme abduction, by means of a plaster spica bandage, which should include the foot, until the union is firm."

2. **SUBTROCHANTERIC DIVISION OF THE FEMUR.** This is a method performed by Watson Cheyne. A vertical incision 1 in. long is carried down to the bone from just below the upper border of the great trochanter. The bone is cleared with a rongeur, and divided transversely, just below the lesser trochanter, with a fine-bladed saw. The great trochanter is then pushed as far forward as it will go, while the leg and the lower portion of the femur are rotated inward, until the limb is in a position of complete internal rotation. Lane's plate and screws are then applied to the two fragments, as for a simple fracture, holding them in the above position. No provision is made for drainage. A plaster spica splint is applied which includes the foot, which is held in internal rotation.

OSTEOTOMY OF THE NECK OF THE FEMUR.—Osteotomy of the neck of the femur is but exceptionally called for and should be avoided. The joint is most certainly opened with its consequent dangers. Necrosis of the head has occurred, as well as suppurative infections of the joint with ankylosis or death resulting. Osteotomy is to be considered in the treatment of malpositions with bony ankylosis of the hip, due either to fracture of the femur or acetabulum, etc., or to tuberculous arthritis of the hip. Careful consideration should be made of the cause of the ankylosis in order to determine the best plan of treatment. For example, in a case of ankylosis due to fracture, one would prefer to do an arthroplasty with a view to securing some motion, whereas in ankylosis due to tuberculosis arthroplasty is likely to relight the process and cause its dissemination. In tuberculosis an osteotomy outside the joint would be preferable, disregarding the ankylosis in the joint but putting the bone in good position.

SUPRATROCHANTERIC OSTEOTOMY.—A. SUBCUTANEOUS WITH SAW (ADAMS' OPERATION).—This operation should be done only when the neck of the femur is of normal length. It has the disadvantage of opening the joint. Make an incision about ½ in. long midway between the top of the great trochanter and the anterior superior spine. Push the knife on parallel to Poupart's ligament until it encounters the neck of the femur. Leave the knife in situ. Pass an Adams' or Jones' saw alongside the knife until the teeth of the saw are in contact with the femoral neck. Remove the knife. With the saw divide the bone. While sawing, one is liable to pull Adams' saw out of the cut in the bone and have much difficulty in reintroducing it. The hook or beak on Jones' saw prevents such an accident. Before obtaining complete rectification it may be necessary to divide the adductor tendons, sartorius, and possibly the rectus. Apply sterile dressings and immobilize the limb in a position of slight flexion and abduction.

B. DIVISION OF THE FEMORAL NECK WITH CHISEL THROUGH A SMALL INCISION.—Division of the neck of the femur is suitable in cases of bony ankylosis where flexion is the only deformity present. The patient is placed on his sound side. At a point immediately in front and above the great trochanter make a 1 in. vertical incision down to the neck of the femur. Introduce an osteotome alongside the knife and remove the latter. Turn the edge of the osteotome transversely to the neck of the femur and divide it completely. Do not, as in the operation for genu valgum, partly divide and partly fracture the bone; this might result in dangerous splintering. Apply sterile dressings. Immobilize the limb in good position, and treat the case as a simple fracture.

TROCHANTERIC OSTEOTOMY. Barton used this method, but it is no longer employed. The line of section was through the great trochanter.

INTERTROCHANTERIC OSTEOTOMY.—(BINNIE'S MODIFICATION OF SAYRE'S OPERATION.)—The object of this procedure is to obtain a mobile joint. Make a V-shaped incision, having the great trochanter midway between its anterior and posterior limbs, reaching from immediately above to a point about 5 or 6 in. below. The open end of the V incision is directed upward and the distance between the two vertical portions of the V is about 2½ to 3 in. Reflect upward the V-shaped flap, which must consist of skin, subcutaneous tissue, and fascia lata (as Murphy's arthroplasty). Pass a Gigli saw around the femur between the 2 trochanters and divide the bone transversely, or the division may be made with the osteotome. With a gouge and rongeur excavate a bowl-shaped depression in the mass of fused bone (trochanter major, head and neck of femur and ilium), which represents the ankylosed hip. Separate the fascia lata from the reflected V-shaped flap, leaving it attached by its base. With this flap line the newly made cotyloid cavity. With rongeurs round off the upper end of the lower fragment of femur and fit it into the new cotyloid cavity. Close the wound. Apply dressings and extension. When the wound is healed begin motion.

SUBTROCHANTERIC OSTEOTOMY.—The advantages of this over the supra- or intertrochanteric osteotomy are (Binnie, 2):

1. Ease of performance.

2. Remoteness from articulation, which is important in tuberculous disease.

3. Section is below the insertion of the psoas muscle, which might cause occurrence of the malposition, if it could still act on the lower fragment.

There is a difference of opinion as to (a) the direction of the osteotomy line (transverse or oblique from below and without, upward and inward); (b) the type of osteotomy which is best (linear or cuneiform); (c) the level of the division (subtrochanteric, intertrochanteric); (d) whether the simple linear osteotomy should be performed subperiosteally, that is, after raising up the periosteum, which requires a broader soft part opening, or whether it may be done without raising up the periosteum. Orthopedists seem to prefer the subperiosteal method, but the other procedure appears to give equally good results, since the periosteum is preserved. In general only about three-quarters of the thickness of the femur is chiseled, the remainder being broken.

A. Transverse Linear Subtrochanteric Osteotomy (Gant's Operation).—At a point 4 fingers' breadth below the tip of the great trochanter over the external surface of the femur make a vertical incision down to the bone. The incision must be of sufficient length to permit the easy introduction of an osteotome. Introduce a coarse osteotome with its cutting edge parallel to the wound; when the osteotome reaches the bone turn it so that its cutting edge becomes transverse to the long axis of the bone. Pass the osteotome forward until the anterior aspect of the femur is recognized, and make it penetrate into the bone. Do this likewise on the posterior aspect and penetrate through the cortical bone. Pass a finer osteotome along the face of the first one used and remove the latter. The wide groove left by the passage of the coarser gives precision to the use of the finer instrument. Do not completely divide the bone through. The osteotome ought not to be removed from contact with the bone until the bone section is completed, as its introduction through the small incision in the soft parts is a matter of much difficulty. Remove the osteotome and cover the wound with an aseptic dressing. Complete the rectification of the deformity by breaking the partially divided femur. Apply an immobilizing splint in the corrected position. Treat as a simple fracture.

B. Oblique Linear Subtrochanteric Osteotomy (Hoffa, Terrier, Hannequin).—Make a vertical incision 5 or 6 in. in length along the middle of the outer surface of the femur from the top of the trochanter major downward. Separate the periosteum from the bone over its anterior and external surfaces, corresponding with the line of section of the bone. Divide the bone with the osteotome, beginning on the outer surface below and proceeding up and in. Hofmeister says that it is important that the incision end on the inner side above the trochanter minor. Dretmann has revised the obliquity, making it run from above down and in. The advantage to be gained from the obliquity of section is that, when much shortening of the limb is present, extension may cause the divided surfaces to glide on each other, and thus give some lengthening, while the fragments still remain in apposition.

C. CUNEIFORM SUBTROCHANTERIC OSTEOTOMY (VOLKMANN).—Make a 2-in. vertical incision over the external surface of the femur, having its middle at a point about 4 fingers' breadth below the tip of the trochanter major. Reflect the periosteum from the bone over an area involving the width of the bone. With a chisel excise a wedge of bone, which must be so placed as to correct the deformity; for example, if there is a deforming degree of flexion the base of the wedge must be on the posterior surface of the bone; to correct adduction the base of the wedge must be external. Straighten the bone and immobilize.

Osteotomy of Lower End of Femur.—FOR KNOCK-KNEE OR GENU VALGUM. —MACEWEN'S SUPRACONDYLOID OSTEOTOMY OF FEMUR is the classical procedure for knock-knee or genu valgum. Administer an anesthetic. Do not use an elastic constrictor. Place the patient on his back and arrange the limb to be operated upon so that it lies with the outer side of the knee and lower part of the femur resting on a sand-bag. An assistant fixes the limb by grasping the tibia and upper part of the femur. Draw an imaginary line transversely 1 finger's breadth above the superior tip of the external condyle. Draw an imaginary vertical line longitudinally ½ in. in front of the adductor tubercle. Note the point where these lines cross. At this point introduce a long-bladed scalpel or bistoury directly to the bone and, cutting upward, make a longitudinal incision of such size as to admit the largest osteotome. Hold the knife in situ. Pass the largest osteotome of Macewen's series alongside the knife, down to the bone. Turn the blade of the osteotome transversely to the bone, and pass its edge over the bone until it reaches the posterior internal border, and make it penetrate the bone from behind forward and toward the outer side. The maintenance of this direction both guards against division of the posterior wall of the femur and prevents injury to vessels and nerves. After having penetrated the bone for some distance, pass a fine osteotome along the face of the first one used and remove the latter. The wide groove left by the passage of the coarser gives great delicacy to the use of the finer instrument. It is also wise not to divide the outermost layer of bone with the osteotome. This is broken through. With one hand the operator grasps the femur just above the osteotomy division and with the other the lower third of the tibia, and by sudden movements endeavors to rectify the deformity by breaking or bending the partially divided femur. This will often fail on the first attempt, and further chiseling will be required. Over-correct the deformity and immobilize. Both limbs are usually operated upon at the same sitting. Whitman has performed this osteotomy on the outer side, the incision being 1½ in. above the external condyle.

If the point of greatest angle is at the upper end of the tibial diaphysis, then some authorities prefer an osteotomy at that point. A longitudinal incision is made down to the bone on the inner side of the tibia, midway between its anterior and posterior borders at the apex of the angle. The cut should be only large enough to easily admit the osteotome. Introduce the osteotome and turn its cutting edge transversely to the bone. Divide the tibia from within outward, "commencing from the posterior border and raising the osteotome gradually up until it comes into contact with the anterior surface of the lower portion of the tubercle, which is by far the most dense portion" (Macewen). Next divide the dense bone on the outer side of the tibia from before backward. Complete the fracture by manual force. It is necessary to divide the fibula. Morton removes a wedge from the tibia, sufficient bone being excised to correct the deformity. Only when the tibial curvature is much greater than the femoral does the former require division. This is rare.

FOR BOW LEGS OR GENU VARUM. The maximum curve is usually near the knee and is the result of external bowing of the femur and of the leg bones. Before the age of 4 or 5 years mild deformities may be corrected by mechanical appliances; after that age operation affords the only prospect of cure.

LINEAR OSTEOTOMY.—Note which bone or bones are most seriously affected. Usually in typical genu varum both the femur and tibia are badly curved. Note which part of the individual bone is most bent; it is this part which must be divided. The object to be accomplished is to correct the deformity. If division of one bone is insufficient, then divide the other as well; if this be insufficient, repeat the operation at whatever places it may be demanded. Macewen has performed 10 osteotomies on the same patient at the same sitting and obtained a good result.

If osteotomy of the middle third of the femur be indicated, make a vertical incision through the soft parts down to the bone on the outer or antero-external side, and proceed as in supracondyloid osteotomy, in this case cutting the bone from without inward. If the tibia be most affected, incise vertically down to the bone the soft parts over the inner surface of the bone at the point of greatest curvature. Introduce the osteotome and then turn it transversely to the bone and divide the cortical bone of the inner and outer sides of the tibia, and especially that of the anterior margin. Be careful not to injure the anterior tibial vessels and nerves which lie close to the outer surface of the bone. Fracture the posterior layer of the cortical bone by manual force. Forcibly fracture or bend the fibula. If this is impossible, palpate the fibula and make a small incision down to it through the soft structures of the outer side of the leg. Introduce a very narrow osteotome and divide the bone. If the femur and tibia are both markedly curved, operate on both at the same sitting.

CUNEIFORM OSTEOTOMY is particularly suitable in cases of anterior curvature of the tibia.

OBLIQUE OSTEOTOMY (Ollier) is suitable in some cases of anterior curvature of the tibia where there is much shortening, as extension applied to the limb permits of its elongation. To attain this elongation it may be necessary to lengthen the tendo Achillis.

FOR GENU RECURVATUM.—The knee is in a position of hyperextension (dorsal flexion). Further extension (dorsal flexion) is possible, but only adds to the deformity and disability. Excise a rhomboid-shaped piece of bone with base posterior from the femur, the lower limit of the rhomboid being 1/4 in. above the epiphyseal line. Remove so much bone that when the divided ends of bone are put in apposition the whole limb is straight, while the knee joint is in its position of greatest hyperextension. Shortening of the flexor tendons of the knee may be necessary.

FOR BONY ANKYLOSIS OF THE KNEE.—When tuberculosis is the cause of the bony ankylosis it is wise to operate as far as possible from the joint lest encapsulated infected agents be let loose. Operation is indicated when malposition interferes seriously with walking or standing. Contracture of the hamstring muscles may interfere with correction, in which case tenotomy or tendon lengthening is indicated.

1. Linear Osteotomy of the Femur.—On either the inner or outer side of the rectus tendon, on a level with a line drawn transversely, a finger's breadth above the upper portion of the external condyle, make a longitudinal wound sufficient to admit a Macewen's osteotome. Proceed exactly as in supracondyloid osteotomy.

2. Linear Osteotomy of Both Femur and Tibia.—When section of the femur alone is insufficient, to it may be added a linear osteotomy of the tibia immediately below the anterior tubercle. Instead of making a linear osteotomy of the tibia, Wendorff excises a wedge of bone (with its periosteum) with its base anterior. This not only helps in correcting the deformity, but provides a fragment of bone which he inserts into the cleft left in the femur, after it has been divided and straightened.

EXCISION OF THE DIAPHYSIS OF THE HUMERUS

The incision is vertical along the lateral biceps furrow. The biceps and coracobrachialis are retracted inward and the triceps outward. In this way the middle two fourths of the humerus can be exposed without danger of injuring important structures, particularly the musculospiral nerve. The periosteum is incised and reflected, following which the operation is done entirely subperiosteally. In case one wishes to operate on the upper fourth of the diaphysis, the incision should run somewhat obliquely upward, following the median edge of the deltoid. The deltoid is then retracted upward and outward and the cephalic vein either doubly ligated and divided or retracted inward. It is usually not necessary to carry the incision upward above the middle of the deltoid. In the lower fourth the incision runs in the space between the brachialis anticus on the inner side (retracted inward) and on the outer the supinator longus (retracted outward), while the musculospiral nerve is retracted externally and backward. In the lower fourth the end branch of the musculocutaneous nerve is observed, running between the brachialis anticus and biceps, where it breaks through the fascia just above the lateral epicondyle, at which point it becomes a cutaneous nerve. In some cases, particularly after complicated fractures with excessive callus formation, the relations may be difficult to make out. In such cases the advice of Olliers should be followed, which is to dissect out the musculospiral nerve, as the first proceeding, so that it shall not later be unwittingly injured.

The attack of the humerus from behind should be avoided, since damage to the musculospiral nerve is more than likely to follow, as it gives branches to all three divisions of the triceps.

EXCISION OF THE DIAPHYSIS OF THE ULNA

This is comparatively simple since the ulnar posterior border from the olecranon to the styloid process is not covered by muscles and is therefore easy to palpate and to lay bare. The incision along the posterior border is at the same time the boundary line between the dorsal and ventral fascial leaves. After subperiosteal, blunt raising up from the bone of the anconeus, on the dorsal side of the extensor carpi ulnaris, and the flexor profundus digitorum with the flexor carpi ulnaris on the volar side, almost the entire circumference of the ulna is free, which will allow any of the procedures already mentioned to be performed.

EXCISION OF THE DIAPHYSIS OF THE RADIUS

The upper end of the radius alone is best exposed by Kocher's lateral incision for resection of the elbow joint (which see).

For the exposure of the entire diaphysis the forearm is placed in an obtuse-angled flexion in the mid-position between pronation and supination. The incision is made along the outer surface of the radius on its back side, from the palpable head of the radius almost to the styloid process. The skin edges are retracted to each side. The fascia is split between the broad tendinous origin of the extensor carpi radialis brevior on the anterior side and the extensor communis digitorum on the posterior side. In the upper part of the incision appear the obliquely running fibers of the supinator brevis covering the radius. This muscle is sharply divided upon the bone, beginning below and proceeding upward. At the finish of the operation the divided ends are again united. The muscle at its upper part must be divided with great care, since the posterior interosseous nerve runs obliquely through the muscle. About in the middle of the radius the broad insertion of the pronator radii teres is met with, and this should be separated subperiosteally from the bone. Below the middle the extensor ossis metacarpi pollicis and the extensor primi internodii pollicis are drawn posteriorly, while in the lower third the superficial branch of the radial, running obliquely posteriorly over the last-mentioned muscle, is avoided. In the lowermost angle the tendon of the extensor carpi radialis brevior runs posteriorly.

Kocher gives another method of exposure which assures perhaps the least danger of damage to important structures. The incision is made along the anterior surface and runs along the ulnar edge of the supinator longus and corresponds with that for the extensive exposure of the radial artery. The artery is retracted toward the ulnar side, while the radial nerve is drawn toward the radial side, thus avoiding injury to them. In the distal third the insertion of the pronator quadratus should be divided temporarily, transversely to its fibers; in the middle the pronator teres; and in the upper the supinator brevis.

If the question is the infrequent one of total extirpation of the radius, the middle of the shaft should be sawn through and the 2 halves should be separately exarticulated. Extensive regeneration of bone will take place if the excision be done subperiosteally, as after diaphyseal tuberculosis or acute osteomyelitis.

EXCISION OF THE FEMUR

One can expose the femur without injuring important structures only from the lateral side, preferably the outer side. One proceeds by separating the vastus muscle, which arises from the whole length of the linea aspera, from the biceps muscle. The leg is slightly flexed. The incision extends from the middle of the trochanter to the external condyle, so that it lies just behind the lateral edge of the vastus. The iliotibial band is divided and the posterior edge of the vastus is identified, and then separated from the biceps, exposing the linea aspera. In order to reach the trochanter from the linea aspera it is necessary to separate the gluteus maximus muscle subperiosteally from the outer border of the linea aspera and to retract it forward.

EXPOSURE OF THE POPLITEAL SPACE

This can be accomplished either from the inner or the outer side, depending on the indications, e. g., the presence of fistulæ or of abscesses.

A. From the Inner Side.—The limb is held in strong outward rotation and in right-angled flexion at the knee. The skin incision is made in the long axis behind the posterior edge of the adductor magnus tendon. After splitting the fascia lata, one proceeds between the median intermuscular septum and the semimembranosus tendon down to the bone, retracting the muscles apart with blunt retractors. The entire vessel and nerve bundle is raised up subperiosteally in toto from the bony popliteal plane and held to one side by large blunt retractors.

B. From the Outer Side.—The limb is held in adduction, inward rotation and slight flexion at the knee. The skin incision is made between the vastus externus and biceps muscles. The vastus externus arises from the whole external lip of the linea aspera, and one arrives at the femur with least damage along its back surface. The biceps and vessels are retracted posteriorly.

RESECTION OF THE TIBIA

A. Resection of the Tibial Head.—The excision of the entire tibial head is exclusively required for sarcoma. As a result of this operation a defect 10 to 12 cm. long results in the bone, which comprises practically all the lower part of the knee joint. This defect must be filled in in some way. In order to avoid having the scar come over the subsequent implant the incision should lie over the fibula side, as in Kocher's incision for resection of the knee joint. The incision begins 3 fingers' breadth above the upper edge of the patella, proceeds vertically downward, 2 fingers' breadth from the lateral edge of the outer side of the patella, to a point 3 fingers' breadth below the lowest extent of the tumor, where it curves forward over the anterior edge of the tibia. The fascia is split in the same plane and laterally from the quadriceps tendon the knee joint is opened. The extensor apparatus is drawn toward the inner side, and the ligamentum patellæ is divided at the tuberosity of the tibia, or, if the case allows—e. g., cyst in the tibial head—the tuberosity of the tibia is circumscribed with a knife and then chiseled out of the bone. The crucial ligaments are divided and the tibial head on all sides is isolated by dividing the muscular attachments. The tibia is divided with the Gigli saw beneath the lowermost sarcoma boundary, which has been previously determined by the X-ray. The chisel had best not be used since splintering may be caused with extension of tumor tissue into the wound. Proceeding from within outward all remaining soft part connections are divided and finally the ligament joining the tibia with the fibula. The bleeding at this stage is usually severe. After extirpation of the head, all bleeding is controlled.

As for the filling in of the defect thus arising three measures are considered: 1. The wedging of the pointed fibula into the femur at the intercondyloid notch. To do this the fibula end is chiseled so that it becomes pointed and about a 2 cm. round, deep hole is made in the intercondyloid notch to fit the fibula, which is driven into the hole. 2. The transplantation of the intact fibula head into the intercondyloid notch. This will hypertrophy functionally and the procedure has the advantage of eventually giving motion at the new femur-fibula joint. The intact fibula head must be firmly placed in a smooth cavity of the femur, and the ligamentum patellæ must be fastened to the fibula. Periosteal fixation is not certain enough. The surest way is to drill the fibula and to fasten with chromic gut sutures the ligamentum patellæ through the drill holes.

3. A better method to fill the defect than the previously described procedures is to implant the upper portion of the fibula with periosteum taken from the other leg. The section to be transplanted should be longer than the defect itself and should be driven into the medullary cavity of the lower tibial stump. The weight of the body should not be allowed on the transplant until eight months to a year have elapsed.

PARTIAL OR TOTAL RESECTION OF THE TIBIA

For the resection of the diaphysis of the tibia a similar incision is used as for necrotomy. These resections are usually for sarcoma, whose extent is previously ascertained by röntgenograms. One should always be sure to isolate the tibia through healthy tissues. The incision is begun in the neighborhood of the tuberosity of the tibia, higher or lower as the case may be, and swings in a broad curve 2 fingers' breadth internally from the anterior edge of the tibia downward to a point beneath the future division of the tibia. The soft parts are dissected up, exposing the tibia. The fascia and the muscles are divided by a knife in healthy tissue. The periosteum is removed with the bone, if the resection be for sarcoma. The division of the bone should be done with a Gigli saw, and not with a chisel, for fear of splintering the bone with consequent scattering of sarcomatous material into the wound. An Esmarch tourniquet had best not be used because the subsequent oozing may endanger the life of the transplant.

The various endeavors made to fill in the defect are interesting. In partial diaphyseal tibial defects the only procedure which seems worthy of imitation is the implantation into the medullary cavities of the remaining stumps of a section taken from the opposite healthy fibula, together with its periosteum. The fibula is preferred because its loss occasions no disturbance in function, or a bone section may be removed with periosteum from the opposite healthy tibia. Bittner filled in a defect of the lower tibial diaphysis by a bony bridge comprising almost half of the upper part of the tibia. The tibia was drilled just below the tuberosity transversely through its middle and the anterior half was separated transversely by a Gigli saw. The anterior half was then separated vertically downward by a Gigli saw. The tibial bridge was then so transplanted into the defect that the upper broad end came to lie below upon the epiphysis, where it was fastened with interrupted silk sutures. The upper end was then fastened to the raw end of the tibia by the same sutures. There resulted good consolidation and good function. At first the growth of the tibia seemed to be inhibited, later it appeared to be increased.

If the entire diaphysis should have to be removed for osteomyelitic necrosis, the periosteum should be preserved and enough of a shell of bone to be left upon it to preserve its continuity and to prevent deformity since a human transplantation in presence of infection is out of the question.

RESECTION OF THE FIBULA

The least damaging access to the fibula in its entire extent lies behind the peroneal muscles. Above the external popliteal nerve crosses the fibula head in a spiral fashion. This nerve is first dissected free and drawn forward. The entire diaphysis of the fibula is then accessible after the peroneal muscles are drawn forward. The manner of exposing the fibula in front of the peroneal muscles is to be avoided, since here the anterior tibial nerve runs in its entire length directly in front of the fibula, so that subsequently the nerve is liable to become involved in the scar tissue. Resections of the fibula do not injure the functions of the limb in the slightest. It is, therefore, frequently used for free periosteal bone transplantations. The lower fibula end must be preserved, however, since the mortise of the ankle joint and with it the position of the astragalus and os calcis depends upon it.

THE EXTIRPATION OF SINGLE TARSAL BONES

Extirpation of the Astragalus. In this operation, one must remember that the astragalus is anchored in a close ligamentous union with the neighboring bones. The incision is made from the front of the external malleolus parallel and external to the peroneus tertius muscle over the ankle joint. This is opened and the joint capsule is dissected away externally and internally. The ligaments on the outer side are divided and then those on the inner side, this latter being assisted by strong adduction and prying out of the astragalus.

The extirpation of the astragalus is indicated in isolated tuberculosis, in severe fractures and dislocations, and in club foot.

Extirpation of the Calcaneus. Of the usual incisions for the exposure of the calcaneus, the simplest is that of Landerer, who makes a median incision over the Achilles tendon and into the sole. The calcaneus is thereby well exposed, the only objection being that the scar lies in part on the plantar surface, which, according to Landerer, does not prejudice walking, but is avoided by many surgeons. Another incision is a posterior, horizontal arched incision, which divides the Achilles tendon at its insertion and which reaches forward to the front boundary of the calcaneus. Kocher makes an external curved incision and adds to this a vertical incision along the internal side of the Achilles tendon. The further procedures are alike in all the incisions. The flaps are dissected up from the bone, the Achilles tendon divided at its insertion, the posterior part of the ankle joint opened, the outer side bared after raising up the peroneal tendons, and the strong interosseous ligament divided. After cutting the external calcaneocuboid ligament, the calcaneocuboid joint forward is opened, the flexor tendons are drawn upward on the posterior internal side and the remaining attachments on the internal side are divided. During these entire procedures the calcaneus is drawn from side to side by a lion-toothed bone forceps.

Extirpation of the Scaphoid.—The scaphoid bone is exposed through an incision parallel to the tendon of the extensor longus hallucis. The periosteum is divided and separated all around, and the capsule attachments with the three cuneiform bones and the astragaloscaphoid articulation are subcapsularly divided. The extirpation follows subperiosteally and subcapsularly. It is indicated in isolated bone foci in the scaphoid and in club foot.

RESECTIONS OF THE CLAVICLE

But few bones can be exposed as easily as the clavicle, since throughout almost its whole extent it is covered only by skin. The exposure of the healthy bone occurs only as a preliminary act in the course of other operations and can be made transversely, i. e. in the direction of the clavicle, or, in a circumscribed exposure, it can be made vertically with lateral retraction of the soft parts. The technic is similar to the subperiosteal rib resection. If the question is of exposure of the bone in diffuse fractures, pseudarthroses, tuberculosis, or osteomyelitic necrosis, then the technic is scarcely any more difficult, particularly if one can work subperiosteally. These procedures are to be considered "typical," and with those the transverse or oblique temporary osteotomy and the division in continuity, whether they be undertaken for the purpose of exposing the structures lying back of the clavicle as a preliminary step in other shoulder operations, or whether the diseased bone itself is to be removed. Considerable difficulty is often met with in extirpating the clavicle for new growths in case these have reached a considerable size.

The following are some of the procedures:

1. **Temporary Osteotomy of the Clavicle.**—This procedure is valuable for extensive exposure of the retroclavicular vessels and nerves. The best incision is a vertical one which begins above the middle of the clavicle and proceeds perpendicularly or somewhat obliquely laterally over the clavicle and pectoralis major muscle. This muscle may then be divided as much as is necessary transversely to its fibers. The wound edges are retracted to each side and the periosteum is circularly divided and separated for 1 cm. A blunt, flat instrument, such as an elevator or Kocher's goiter sound, is inserted behind the bone from below upward, and a Gigli saw is passed behind the bone, which is divided obliquely from above internally downward and outward. This works against the pull of the sternomastoid. Blunt hooks are passed beneath the ends of the sawn surfaces and these are drawn upward and thus apart. This separation occurs most extensively when the ligaments fixing the clavicle are divided, i. e. ligamentum costoclavicular, ligamentum coracoclavicular, and finally the subclavius muscle with its fascial capsule. Simple wire or silk suture, after finishing the operation, suffices for consolidation.

2. **Resection in continuity of the clavicle** is best done by an incision in the soft parts parallel to the long axis of the bone. Where suitable, the periosteum is split in like direction on the front surface and the bone is removed subperiosteally as in resection of the ribs. Callous masses lying behind furnish occasional difficulties, particularly in the vicinity of the great vessels and of the plexus.

3. **Total resection of the clavicle** is performed by a long incision in the long axis of the clavicle, which divides skin, platysma and supraclavicular sensory nerves. Suspicious skin, overlying tumors attached to the skin, will require circumscribing and excision, which may necessitate the subsequent

formation of one or several flaps. In tuberculosis and in osteomyelitis, in the fistulous stage, the ends of the clavicle can often be retained, but the rule should always be followed that in all cases of malignant growths, the total resection of the entire bone, together with its periosteum, should be undertaken. The separation and freeing of the bone will begin most easily at the joint whose clavicular part is least diseased. If one has a choice, according to the views of most authors, the separation had better begin in the acromioclavicular joint. This is opened at once by a strong scalpel, which below is turned toward the sternum and with the knife held close to the bone, the coraco-acromial, coracoclavicular, as well as the posterior ligaments of the joint are divided. The clavicle, which has now become more mobile, is progressively held up and then separated. Above the trapezius, below the deltoid and subclavius, clavicular portion of pectoralis major, above medianly the clavicular insertion of the sternomastoid are all divided. The final act consists in the separation in the sternoclavicular joint, which requires the division of the powerful costoclavicular ligament and the capsule strengthening the sternoclavicular anterior ligament. The final separation is made easier by turning motions of the clavicle. Proper care is to be taken of the very friable veins lying immediately behind the joint. Particularly difficult are the relations, if the sternal end of the clavicle is involved in the tumor. In such a case it may be wise to remove a piece of the manubrium of the sternum. After the removal of the clavicle, there follows, whenever possible, the suturing of the muscles (trapezius to deltoid, sternomastoid to pectoralis). After allowance is made for drainage, usually in 2 places, the skin is closed.

The loss of the clavicle, even with its periosteum, causes no severe disturbance in function.

4. **Segmental resection of the clavicle** for osteoplastic purposes, not only in the sense of free autoplasty, but also in the formation of skin-periosteal-bony flaps has often been performed, particularly for making up a loss of the lower jaw. The technic of this procedure is very simple. It should be remembered that the clavicle is brittle, hence the chisel is unsafe. A Gigli saw should be used. Another disadvantage is the loose connection of the periosteum with the skin.

OPERATIONS ON THE SCAPULA

The following are the more or less typical procedures on the scapula:

Exposure of the Scapula.—Exposure of the bone is necessary in complicated fractures, osteomyelitis, necrotomy, and partial resections (with chisel), also exposure of an edge for muscle or callus removal. For the exposure and resection of the spine of the scapula and the neighboring part of the body, the normal incision is one over the palpable free edge of the crest of the spine, to which can be added, if necessary, a second incision along the median edge of the bone. The patient should lie upon the healthy side. The incision directly exposes the crest. According to the position of the disease, the spine can be freely exposed, after separation with the elevator of the insertions of the trapezius above and of the deltoid below, by blunt separation of the supraspinatus above and the infraspinatus below. If one is compelled to separate further toward the neck of the scapula, care should be taken not to injure the transverse scapular artery and the suprascapular nerve, running in front of the inferior transverse scapular ligament. The nerve can be exposed to sight laterally from the external free edge of the spine in the depths between the supra- and infraspinatus muscles. For the exposure and resection of the lowermost portion of the scapular body, according to the situation and extent of the disease, a smaller or greater incision is required, preferably running along the median, vertebral edge of the bone. The aponeurosis and lowermost fibers of the trapezius are then separated. One then either bluntly separates the fibers of the infraspinatus or proceeds between this muscle and the teres major, or, in case more extensive exposure is necessary, sharply divides the origin of the infraspinatus from the median edge. The muscle is then bluntly separated and laterally retracted. The suprascapular nerve, which supplies the muscle, is thus most surely avoided.

Subtotal and Total Resection of the Scapula.—Malignant new growths furnish practically the single indication for this infrequent operation. One speaks of subtotal resection when either the processes or the joint surface or all 3 structures are not removed. This is possible in certain instances, in which case it is of great advantage for the function of the arm. The technic of both procedures in the main is alike and therefore they will be described together. Large incisions are indispensable. The patient lies on the healthy side. The first incision runs along the vertebral edge of the scapula from the upper to the lower angle, and to this is added a transverse incision from the acromion to the first incision. The skin is reflected in the form of two triangles, so that the fascia overlying the scapula is everywhere exposed. From the upper lip of the spine of the scapula the insertion of the trapezius is sharply divided, and above the aponeurotic part of the same muscle is separated from the vertebral edge and reflected internally. Next the origin of the deltoid is separated from the acromion and the spine. The upper internal edge of the scapula is lifted up from the thorax, which puts the muscles on the stretch, thus rendering the separation of the rhomboids and the scalenus anticus from the internal border easy. As soon as the separation of the muscles around the lower angle is completed, which is facilitated by the arm being brought over the chest, the scapula becomes mobile and is brought into a sagittal position, which renders further separation easier. There follows then progressively the separation of the muscles inserted into the upper edge: the levator scapulæ and the omohyoid. The scapula is now better able to be elevated from the chest but still is attached to the clavicle by ligaments and to the humerus by the scapulohumeral muscles. The muscles to be next separated are those which surround the shoulder joint. The involvement of the joint surface in the new growth is next determined. If the glenoid and the closed joint can be retained, then the latissimus, teres major and minor need not be sacrificed, but should later be fixed to the thorax. The supraspinatus and infraspinatus are practically always sacrificed, and are divided as they become tendinous. The circumflex nerve met with on the lower edge of the teres minor and supplying the deltoid, is avoided. Finally the broad subscapular tendon is divided on the front median side. In the subtotal resection the acromion, the coracoid process and the glenoid process are divided with the chisel. Easier is the total resection, for which purpose at first the shoulder joint capsule is opened above and behind, followed by division of the long biceps tendon and the tendon of the outer rotators. Then the subscapular tendon is divided from above with the arm outwardly rotated. The separation of the coracoid process, on account of its strong ligamentous attachments, is difficult. Therefore, its retention, or at least the retention of its end, is advisable because at the finish of the operation, by fixation of the process to the thorax, a better support is afforded to the three muscles attached to it. Dangerous hemorrhage can be avoided by a progressive division of the muscles, with immediate grasping of the numerous muscle arteries. It is usually necessary, for the sake of thoroughness, to remove the muscles lying upon the front and back of the scapula.

BONE GRAFTING OR TRANSPLANTATION

Bone transplantation has become a well-recognized and successful surgical procedure. Perhaps no one subject in surgery has created a greater discussion than the function of the periosteum in bone transplants and what it accomplishes. To understand the subject it will be necessary to give the three differing views of leading authorities as to the life of grafts.

1. The universally accepted view in Germany is that of Axhausen, who maintains that the bone in a graft always dies, is absorbed and is reformed from the periosteum, which alone remains living in transplants.

2. The second view is that of Macewen, of Glasgow, who says that the bone in a graft is reproduced from the proliferation of osteoblasts, derived from the osteoblasts within the bone of the graft itself, and its regeneration takes place independently of the periosteum, whose only function is that of a limiting membrane, which prevents the spread of the osteoblasts into the surrounding tissues.

3. The third view is that of Murphy, who says that the graft is not osteogenetic but simply osteoconductive. Provided it be in contact at one or both extremities with other living bone, the graft acts simply as a scaffolding for the growth of the capillaries with their osteogenetic cells as they advance from the living, contacting extremities into the graft. The periosteum takes no part in the actual reproduction of new bone. To analyze Dr. Murphy's transplantations a little further, I may say that I have gone through all of his reported transplantations with the object of finding out just what was done with the periosteum in each procedure. In a number of cases this was not stated. In all such instances I have ascertained from him in writing exactly what was done with the periosteum. In not a single instance did he omit to transplant grafts

with more or less of their covering periosteum. From a practical standpoint I judge that he does not know just what would have happened had he transplanted grafts without their periosteum, so that his conclusions as to the function of the periosteum are conjectural only.

We know that practically every graft made with its periosteum will permanently live, if asepsis be attained. What will happen to grafts made without their periosteum? Following the publication of Macewen's monograph, "The Growth of Bone," in which no osteogenetic power is attributed to the periosteum, I made 4 human transplantations without periosteum and in every case the graft was ultimately absorbed. That led me to perform a large number of animal experiments, which have been published in full (9). Every graft made with periosteum lived. Of 25 grafts made without periosteum but 48 per cent. lived. That led me to conclude that the blood supply of the graft was the all-important factor. Since we have no way of knowing in which cases the blood supply will be sufficient if grafts be without their periosteum, the conclusion seems irresistible that grafts should always be made with periosteum upon them. This will assure subsequent life to practically every graft so made if asepsis be obtained. The conclusions that I formulated with a proof of each are as follows: They form a fairly complete set of rules for making transplantations:

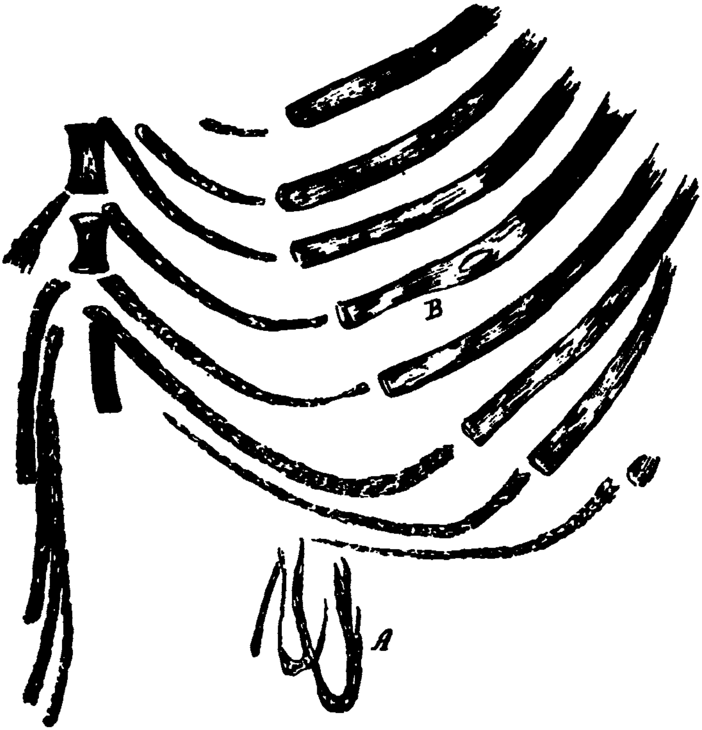

FIG. 36.—TRANSPLANTATION OF SECTION OF RIB INTO ABDOMEN. A section of a rib, B, was subperiosteally resected. This was split into longitudinal strips and transplanted into abdomen. Result: new bone B has entirely filled in the defect in the rib because the periosteum was left. The strips A into the abdomen have remained alive, have grown together and have increased in size.

1. **If a section of the whole diameter of a bone be removed, then the bone will regenerate between the ends of the fragments, if the whole, or a part of the periosteum, bridging the defect, be preserved.**

Proof: Experiment 3 (Fig. 36). This animal was killed 8 months after subperiosteal resection of a section of a rib (B). This rib without periosteum was then split into longitudinal strips (A) and these were transplanted into the abdomen. Result: The defect in the rib, from which the periosteum was not removed (B) has become entirely filled in with new bone. The strips (A) transplanted into the abdomen have remained intact, have grown together, and have increased in size. A photomicrograph of a section of this abdominal transplanted bone shows bone perfectly alive, not undergoing absorption, and containing well-preserved and normal marrow. I attribute the living of these transplants to the fact that the splitting of the original rib allowed sufficient blood to get to the bone cells.

This is a refutation of Dr. Murphy's conclusion, in which he says that bone, with or without its periosteum, when transplanted into the soft parts and not in contact with living bone, always becomes absorbed. This was one of the cases in which the graft transplanted without periosteum did not become absorbed. I have a number of such experiments.

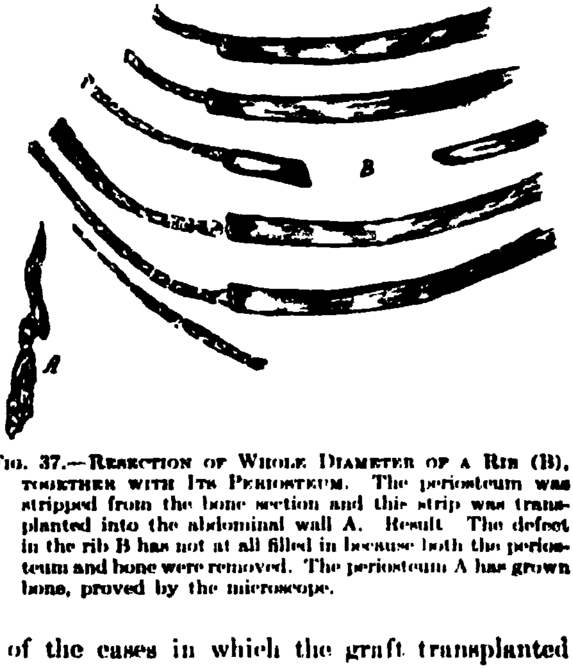

Fig. 37.—Resection of Whole Diameter of a Rib (B), together with Its Periosteum. The periosteum was stripped from the bone section and this strip was transplanted into the abdominal wall A. Result. The defect in the rib B has not at all filled in because both the periosteum and bone were removed. The periosteum A has grown bone, proved by the microscope.

2. **If a section of the whole diameter of a bone be removed, there will take place very little subsequent filling in of this defect by new bone, if the entire periosteum has been removed from between the ends of the fragments. To have such a defect fill in, it is necessary that there shall be either some portion of periosteum left or a thin layer of bone, bridging the defect.**

Proof: **Experiment 2 (Figure 37). This picture was taken 6 months after resecting the whole diameter of a rib (B) together with its periosteum. The defect has not at all closed in, due to the lack of periosteum. The periosteum was stripped bluntly from the bone section and this strip of periosteum was transplanted into the abdominal wall (A). Result after 7 months: A transverse section was cut through this periosteum (A) which was felt to be bone. A microphotograph of this section gives a picture of normal, healthy, living bone** surrounded by a closely investing connective tissue capsule. There are no osteoclasts present nor any round cells suggestive of either a destructive or an inflammatory process. This result shows that transplanted periosteum may produce living bone, contrary to Macewen's and Murphy's teachings.

3. Provided that a graft be living and taken from the same patient, who is to be grafted, its future life depends on an efficient blood supply, irrespective of either the periosteum, or whether the graft is in contact with living bone or not. This conclusion I desire to emphasize most emphatically. The blood supply is always uncertain and unknown in any individual case. The blood supply seems to be favorably influenced by the periosteum, since 100 per cent. are successful with it and but 48 per cent. without it. Hence the teaching is clear to always transplant grafts with periosteum.

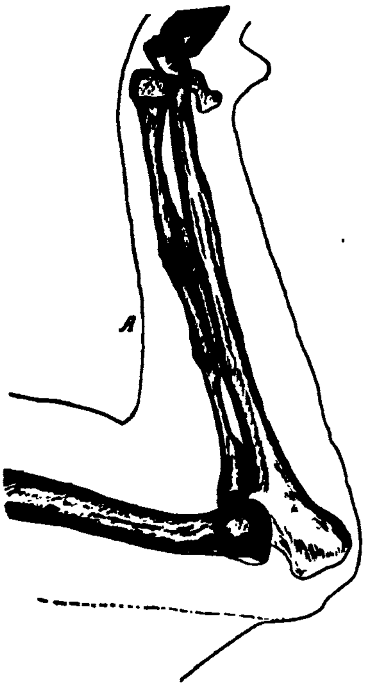

FIG. 38.—ONE AND A HALF INCHES OF RADIUS REMOVED WITH PERIOSTEUM. This was stripped off the bone section which was split into as small fragments as possible. These small fragments were replaced in the defect. Result: these small fragments have remained living, and have coalesced into one piece, A, which has united at both ends with the ends of the radius

4. If minute fragments of a living graft be transplanted, then the periosteum may more readily be disregarded because the osteoblasts in the fragments may not die because of an easier access of blood to them, and the pieces of bone may grow and coalesce and not become absorbed. My statistics show that 50 per cent. of such procedures will be successful.

Proof: Experiment 9 (Figure 38). This animal was killed 5 months after 1 in. of the radius was removed, together with its periosteum. The periosteum was then scraped off the fragment, which was split into as small pieces as possible with the rongeur. These small fragments were replaced (A), filling in the defect in the radius. Result: The small fragments have all remained alive, have coalesced into one piece, which has become united to the ends of the radius fragments. This experiment illustrates the influence of a good blood supply upon grafts, even though without periosteum. See also Macewen's case (p. 184 of his book).

5. If a large piece of living bone be transplanted, then it is much safer to leave the periosteum attached to the graft, in order to be sure of its future reformation, since otherwise osteoblasts in the bone of the graft will probably die because cut off from a sufficient blood supply. The periosteum survives because of its adequate blood supply from the surrounding tissues, its inner

surface forms osteoblasts, which themselves proceed to re-form the bone of the graft, in the event that the osteoblasts within the transplant itself have died from a deficient blood supply. My statistics show that 41 per cent. of procedures are successful in which large grafts without periosteum are transplanted.

Proof: Experiment 23. Dog 423 (Fig. 39). Operation. A section (C) from the right fibula, intact, without periosteum was transplanted into left fibula defect (B) in contact with old stumps. The stumps of the right fibula (D, E) were covered with muscle, which was sutured over them. Under fascia of right leg was placed the entire section (A) from the left fibula with periosteum still on it uninjured, there being no contact of this graft with living bone. Result 81 days after the operation: The section (C) transplanted into the left fibula defect without periosteum has much disappeared. There is a slight line left indicating a persistence of some of it. This disappearance has occurred notwithstanding that it was in contact at both ends with living bone. The difference the presence or absence of the periosteum makes is indicated in the right leg. The section (A) transplanted from the left fibula into the right fibula defect with periosteum has grown larger and seems perfectly alive, this notwithstanding that it was not in contact with living bone. This experiment is another evidence that Murphy is not correct in his statement that grafts must be in contact with living bone in order to live. This experiment would also seem to indicate that the periosteum is the important element in maintaining the life of grafts, probably due to its influencing favorably the blood supply.

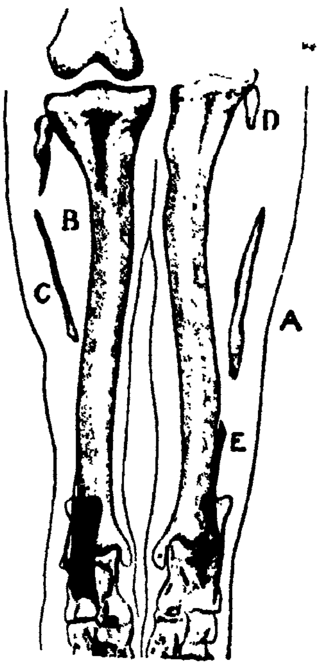

Fig. 39.—A Section (C) from Right Fibula Without Periosteum Transplanted into Left Fibula, Defect (B) in Contact with Stumps. The stumps of the right fibula (D, E) were covered with muscle. Under fascia right leg was placed the left fibula section (A) with periosteum. Result: The section (C) without periosteum into the left fibula defect has much diminished in size as though it were not getting enough blood to keep it alive. The section (A) into the right fibula defect with periosteum, not in contact with the old stumps, has remained living perfectly and seems to be increased in size.

6. Periosteum alone when transplanted into the soft parts may produce living bone.

Proofs: Experiment under conclusion 2, also the following:

Experiment 26. Dog 426 (Fig. 40). Sections from each fibula were excised. From the section from the right side all the periosteum was bluntly stripped off from all sides in one piece. This piece of periosteum (B) was vertically stretched out under the skin of the left leg. The bone itself from the right fibula without periosteum was placed in contact with the ends of the old stumps in the left fibula defect. Over the ends of the stumps of the right defect in fibula, muscle was sutured so that the graft would not be in contact with living bone, and in the superficial muscles of the right leg was placed the section from the left fibula with its periosteum entire. Result 102 days after operation: The section (A) of bone with periosteum in right leg, not in contact with living bone, has grown to 2 or 3 times its normal size and is certainly perfectly alive. The piece of fibula without periosteum transplanted into left defect from right fibula has entirely disappeared. This is probably due to the fact that the bone was transplanted entire. Had it been split as in the preceding 2 experiments, it more than likely would have survived, due to the consequent better blood supply. The periosteum, on the other hand, transplanted under the skin of left leg, has developed a new mass of bone of the size and shape of the old fibula from which it was taken.

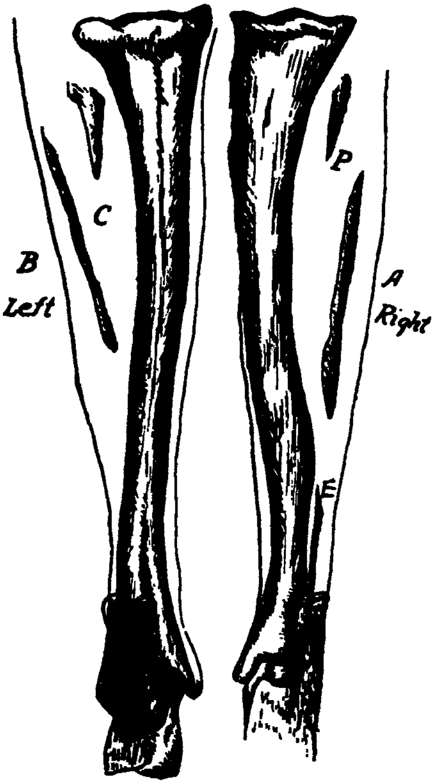

Fig. 40.—Living Bone Produced by Transplanting Periosteum alone. From the fibular section from the right side, all the periosteum was stripped off bluntly in one piece which was vertically stretched out under skin of left leg B. This piece of periosteum has formed a fine new piece of bone B. The right fibula section of bone without periosteum was placed in contact with the ends of the old stumps in left fibula defect. This bone has been entirely absorbed, notwithstanding that it was in contact with living bone. Muscle was sutured over the ends of the stumps of the right fibula defect and in the superficial muscles of the right leg was transplanted the section A from the left fibula with periosteum. Result: this piece of bone A has remained living beautifully, although it was not in contact with living bone.

7. Contact with living bone is not necessary for the subsequent life and permanency of living grafts, as has been maintained by Murphy.

Proof: Experiment 26 (Fig. 40) above.

8. From a consideration of all the foregoing facts, the conclusion seems irresistible that bone grafts of whatever size should be transplanted with as much periosteum covering their surfaces as is possible, if one is to be positively assured of their subsequent survival. It seems probable that the influence of the periosteum is exerted in maintaining the nutrition of the graft. We must conclude that both Macewen and Murphy are mistaken in their conceptions of the lack of function of the periosteum in maintaining the life of grafts. Murphy must likewise revise his conclusion that the graft is not osteogenetic in itself, that it is simply osteoconductive of cells into the graft from the contacting living bone. I have proved that contact with living bone is not necessary for the permanent life of grafts.

Indications for Bone Grafting (modified from Murphy, 10). 1. To correct deformities resulting from defects of development, as aplastic extremital bones—radius, ulna, humerus, tibia, fibula and femur congenital and acquired saddle-nose, aplastic mandible, spina bifida, etc.

2. To produce union in ununited fractures. This is the best treatment and much superior to Lane's plate.

3. To replace bone removed by destructive infections, osteomyelitis, tuberculosis, lues, etc.

4. To restore or supplant fragments dislodged or destroyed by fractures, as the head of the humerus, head of femur, shaft of tibia, etc.

5. To replace bone removed for non-malignant neoplasms, cysts, myeloma, osteitis fibrosa, adamantinoma of jaw.

6. To replace bone removed for encapsulated malignant disease, as giant cell and chondrosarcoma, etc.

7. To immobilize joints, as for example those with too great looseness or imperfect muscular control, resulting from infantile paralysis or Charcot's joint, and for the cure of tuberculosis of joints, as in bone grafting for tuberculous spine (Albee's operation).

General Principles to Be Observed in Bone Transplantations. No cavity which is septic should be filled with transplanted bone, as the graft will die and slough out. All wounds should be perfectly healed before transplantation is attempted.

Most scrupulous asepsis is an absolute essential. No graft should be handled by the operator. It should be grasped by instruments and thus inserted in its new bed.

The living graft should be transplanted always with some periosteum on it. This is most important.

The graft should be taken from the same individual who is to receive the transplant. If this be not possible, then it should be taken from as near a relative as possible. Animal bone should not be used if it is possible to avoid it, because it will be absorbed, owing to the changed serological relations. If taken from another individual, the grafting should not be done until syphilis is ruled out by a Wassermann reaction.

When the head of the humerus or femur is fractured and dislocated and the joint is opened, then the head should be replaced and attached to the freshened lower fractured surface, even though the head be dead, provided it is still aseptic.

All foreign non-absorbable material, wires, nails, celluloid, rubber, etc., should be avoided as implants unless under very exceptional conditions. Encircling wires will erode the bone, and a fracture may result. These non-absorbable foreign bodies tend to irritate, if not invite suppuration, and often produce sinuses which will usually require their removal for complete cure. Chromic gut should be used to fix the grafts in position, avoiding nails and wires for the above reason, and living bone grafts should be taken from the same patient who is to receive the graft, if possible.

A graft increases in size according to the demands put upon it by the organism. Experience has taught that it is not absolutely necessary to laterally fill up a defect completely with a living graft. A much smaller living transplant with its periosteum may be used which will increase laterally to the size necessary. This statement is fixed and settled by many transplantations.

After transplantation, absolute immobilization is essential for success. This should be maintained for at least five months, longer if röntgenograms show its necessity.

An Esmarch tourniquet had best not be employed, since it predisposes to subsequent oozing, and blood would be effused about the graft, whose nutrition is thus injured and the tendency to suppuration is increased.

Methods of Bone Transplantation

(Largely from Binnie)

1. Transplantation of small bone chips with as much periosteum as possible.
2. Transplantation of free non-pedunculated large fragments, always with periosteum covering at least one side.
3. Transplantation with pedunculated bone flaps, the pedicle being either permanent or temporary and the bone taken either from the same bone which is to be grafted or from a neighboring bone.
4. Transplantation combined with arthroplasty, implantation of a part of the length and the whole thickness of the shaft of a bone with one articular end.
5. Transplantation of periosteal flaps (Codivilla's operation).
6. Transplantation for congenital absence of tibia.
7. Transplantation of dead bone, either decalcified bone chips or large fragments.
8. Transplantation of absorbable or non-absorbable foreign material.
9. Transplantation of joints.

1. Transplantation of Small Bone Chips.—Macewen in his book mentions the case of a boy, the whole of whose humeral diaphysis he was compelled to remove for necrosis. There was no subsequent osseous deposition. Fifteen months later the boy was readmitted with the request by the parents that his useless arm be removed. Two wedges of bone were excised from another patient of six years of age afflicted with anterior curves. These were cut into minute fragments, quite irrespective of the periosteum, and were then deposited into the muscular sulcus in the boy's arm. There was no pus formation. Two months later a portion of new bone, 1 in. in length and ¾ in. in thickness, was found firmly attached to the upper fragment of the humerus. Here all the grafts proliferated, grew to one another, and also to the extremity of the proximal portion. Two other wedges of bone of larger size than the first were similarly dealt with and inserted 2 months subsequently to the first graft, and a third couple were placed in position 5 months after the first. These all fused together and to the condyles of the humerus, filled the gap in the arm to the extent of 4¼ in. It is now 30 years since the humeral shaft was rebuilt, and during all that period the man has depended upon his physical exertions for the earning of his living. He worked as a joiner for many years, and is now an engineer's pattern-maker.

Macewen also relates the following experiment. This experiment I have myself duplicated with precisely the same result in several dogs but not always.

The greater part of the shaft of the radius with its periosteum was removed. The shaft of the bone removed, destitute of its periosteum, was then cut into very fine shavings and these shavings were placed between the muscles, which bulged into the gap left in the bone by the removal of the shaft. The neighboring muscles were then attached over the bone shavings in order to keep the shavings in position, and especially to prevent their being extruded from the wound. Examination of the specimen obtained 7 weeks after operation showed that the continuity of the shaft was entirely restored. There was a marked increase in the diameter of the shaft opposite the part where the shavings had been inserted. All the component parts had become fused by osseous tissue into one another and both ends of the shaft.

The method of transplanting small chips does not seem to have as great an advantage as transplanting a large, single fragment with periosteum, for the reason that small chips are less liable to have periosteum on them than large ones, and consequently some of them may die and become absorbed. This I have noticed also by experiment. The teaching seems clear that in simple, comminuted fractures, one should not remove loose fragments, particularly if there be any periosteum on them. They should be replaced, if kept aseptic.

TECHNIC.—Let us suppose the grafting is for ununited fracture. Expose the ends of the fragments, remove all fibrous tissue between them and freshen the ends by sawing them off. The favorite bones from which to obtain the grafts are the tibia, clavicle, rib and upper third of ulna. The tibia is probably the best and easiest. Remove from it, as described under the next section, a length of bone sufficient to bridge the defect with periosteum on 1 or 2 of its sides. With chisel or rongeur divide this piece of bone into small fragments with periosteum on each fragment, if possible. Fill the defect to be closed by these fragments. Close the wound without drainage and immobilize.

2. **Transplantation of Non-pediculated Large Fragments but Always with Their Periosteum.**—Success is assured if the periosteum be on the grafts, and asepsis be attained.

The following case is illustrative of free large bone grafts and shows how important it is to have periosteum on grafts. Two transplantations were performed. The first time Macewen's teaching was followed without periosteum. The graft was absorbed. The second time periosteum was maintained on the graft and the result was perfect.

Case 4 (Fig. 41).—This is an exceedingly interesting case of non-union in a birth fracture of both bones of the leg in a child 17 months old. The non-union I attribute to insufficient immobilization of the leg. I cut down upon the fracture and after freshening the pointed extremities of the fragments, there resulted a defect of 1½ in. in the tibia, which made transplantation of bone necessary. A graft (A) from the opposite tibia was chiseled out with its periosteum. The periosteum was then deliberately peeled off the graft with the object of confirming Macewen's view of its non-importance. One end of the graft was pointed and this was wedged into the medullary cavity of the upper fragment, and the lower side of the transplant was spliced to the side of the lower fragment with chromic gut (Fig. 41). The subsequent union of the wound was by first intention. The next picture shown (Fig. 42) was taken 6 months after the grafting. It was very disappointing to see the tibial graft gradually melt away in the tissues, so that, after 6 months, it was not more than one-quarter its original size. Since union was by first intention, there seems no way of accounting for the death of the graft save on the basis of a lack of periosteum, or of a deficient blood supply, or both.

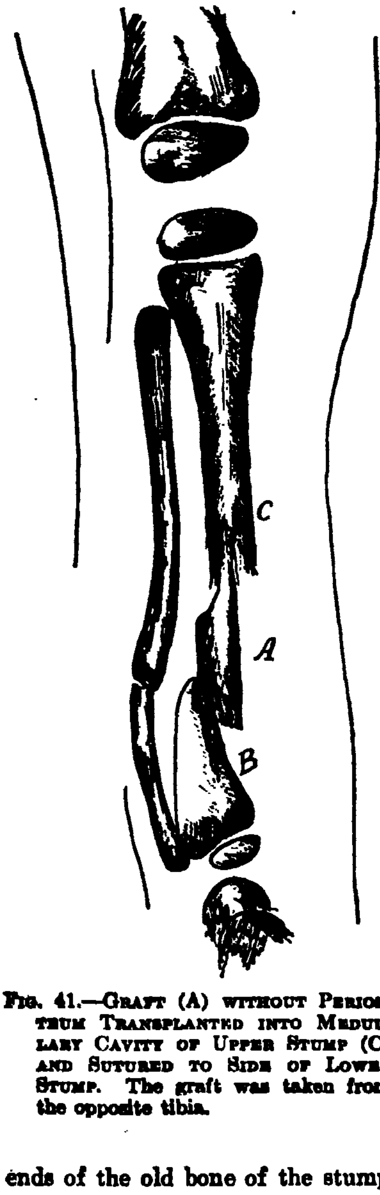

Fig. 41.—Graft (A) without Periosteum Transplanted into Medullary Cavity of Upper Stump (C) and Sutured to Side of Lower Stump. The graft was taken from the opposite tibia.

Six months after the previous grafting operation, I transplanted 5 in. of the opposite healthy fibula into the medullary cavities of the fragments (B, C) as is seen in the picture (Fig. 43 A). It was transplanted with the periosteum covering its entire circumference and this was not split in the slightest. The result shows that this splitting of the periosteum on a graft is unnecessary and accomplishes nothing. Below a wire encircling suture (D) was used to hold the graft in place.

Figure 44 was taken 6 months after the second transplantation. To my mind it seems to imply the necessity of revising Dr. Murphy's conclusion that a graft is not osteogenetic in itself. A fracture (A) has taken place in the lower third of the transplant due to the fact that the child kicked off the splint one night. We see that the upper portion of this fracture of the graft itself is consolidating nicely under an enormous callus (B). If we accept Dr. Murphy's conclusion, we must believe that all this callus came through the graft from the contacting old bone of the neighboring stumps. I do not accept this view for a moment, but believe that the callus arose either from the periosteum or from the bone of the graft itself. Along the outer surface of the graft we see at least ¼ in. of new bone evenly distributed. Were this new bone formed from the contacting ends of the old bone of the stumps, it seems to me that it would shade off, becoming less the further we went from the old bone. As a matter of fact, the greatest amount of new bone is at the fracture spot in the graft, which is at some distance from either contacting extremity of old bone. The lower fragment below the fracture, due to the inhibitory influence of the wire, has scarcely developed at all and it is being eroded by the wire (C). On June 9, 1913, I removed this wire, upon which the lower fragment started immediately to develop. Figure 46 was taken 4 months after the wire was

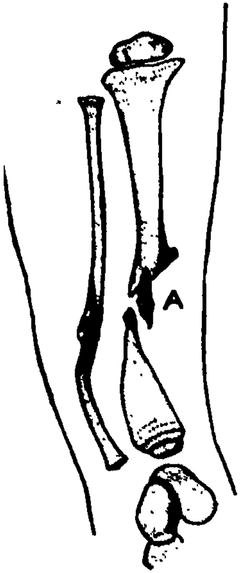

Fig. 42.—Röntgenogram Taken Six Months after Grafting Operation. Indicates absorption of graft A which is not more than one-quarter of its original size and it is moth eaten.

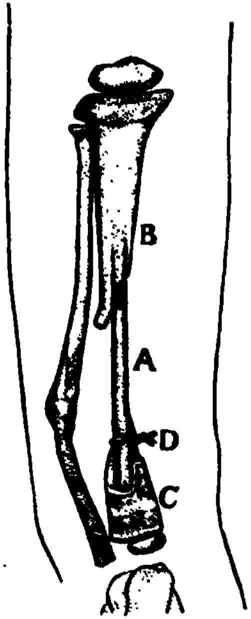

Fig. 43.—Grafting of a Section of Entire Opposite Fibula (A) with Periosteum on All Sides into the Medullary Cavities (B, C) of Fragments. Below an encircling wire suture D was used to hold the graft in place.

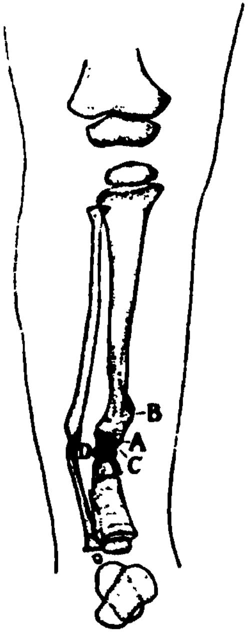

Fig. 44.—Röntgenogram Taken Six Months after Second Transplantation. A fracture A has taken place in the lower portion of the graft, which is consolidating nicely under an enormous callus B. The wire C is eroding the bone.

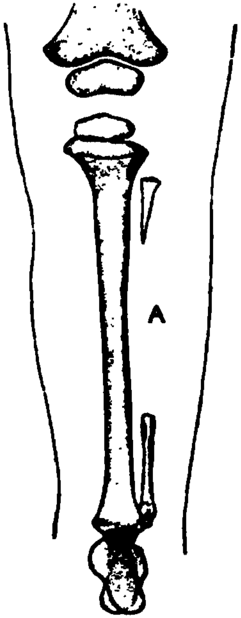

Fig. 45.—Defect (A) in Opposite Fibula Six Months after Removing an Entire Section of It with All Its Periosteum. No evidence of any regeneration of bone.

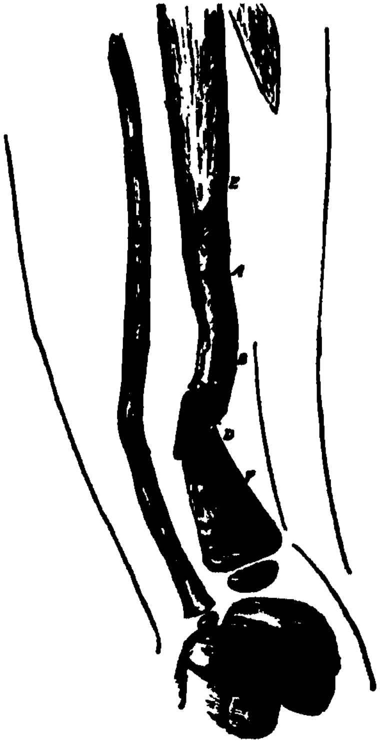

Fig. 46.—Röntgenogram Taken Four Months after Wire in Figure 44 (D) Was Removed. The fracture is healed, the callus almost disappeared and the furrow caused by the wire filled in.

removed. The fracture is healed and the callus has disappeared. Consolidation is progressing nicely between the lower end of the lower fragment and the upper end of the lower shaft.

TECHNIC.—Let us take, for example, an ununited fracture. Expose the ends of the fragments, remove all fibrous tissue from between them and freshen the ends by sawing off sections. The bone graft may be chosen from the tibia, rib, upper third of ulna, clavicle or crest of ilium. If the rib be chosen, periosteum covering its outer surface only should be taken, for fear of opening the pleura. The tibia is the easiest and the most frequently employed bone from which to get the graft. A curved incision through the skin is made beginning at its anterior border with the convexity nearly at the posterior border, ending below at the anterior border again. The flap of skin is reflected off the periosteum beneath. A wide, thin carpenter's chisel is as good an instrument as any to make the graft, and there is no need of a more complicated circular saw. Measure the length of defect to be filled in and add to this sufficient length to permit dovetailing each end into the corresponding medullary cavity of the fractured ends. With the chisel make transverse cuts at the anterior border of the tibia at each end of the part to be transplanted, ½ or ¾ in. deep, the transplant being about as thick as one's forefinger. On the internal surface join the posterior end of each transverse cut by a longitudinal groove, which is made by successive light blows of the mallet on the chisel directed outward, which is moved along after each blow. This is to prevent splintering of the graft. Proceed deeper, the chisel being moved along the groove after each blow. By a longitudinal incision divide the tibialis anticus from the external surface of the tibia without injury to the periosteum, which is longitudinally incised at a distance the same as on the internal surface. Join the posterior ends of the transverse incisions in the bone by a longitudinal groove made on the external surface, the chisel being directed inward through the incision in the periosteum. Proceed deeper until the chisel enters the medullary cavity and then go to the opposite groove and carry this likewise into the medullary cavity. The graft is lifted out by an instrument and is never touched by the gloved hand. The graft should be placed in the defect made for it just as quickly as possible, so that its cells may not die from lack of nourishment. It should not be placed in salt solution as this washes away the little blood that is left on the graft to nourish its cells. Murphy's method is to enlarge the medullary cavities of the fragments with a reamer or burr for a distance sufficient to form a good firm bed for the graft. An equally good method is to make longitudinal furrows opposite to each other on the stumps, large enough to receive the graft. Drill holes are made through the fragments and graft, and chromic gut sutures are inserted through them and tied. Murphy prevents the graft from riding up the medullary cavity by inserting a nail through the fragments and graft, but it seems wise not to use any foreign body which may later irritate. It is not necessary for apposition to be maintained between the ends of the fragments of the fractured bone, though this is desirable. In this way the shortening of the extremity can be overcome. The graft has periosteum on 2 of its surfaces and medullary tissue on the other and will positively live, if asepsis be attained. Both wounds are closed without drainage and the fractured limb is immobilized.

Bittner resected the lower half of the shaft of the tibia for sarcoma, leaving the lower epiphysis. He filled the gap by splitting the remaining half of the shaft longitudinally up into the tuberosity, turning the segment down and fixing it in place. Only 1.5 cm. shortening resulted, and the leg was strong and useful.

3. Transplantation with Pedunculated Bone Flaps, Either Temporary or Permanent.—This method is mentioned for the sake of completeness. It is a serious question as to whether it has any advantages over free bone transplants, which are uniformly successful if periosteum be on the graft and if asepsis be attained. Certainly the conditions will be rare in which pedunculated bone flaps are required.

A. OLLIER'S OPERATION PAR RENVERSEMENT. Expose the ends of the bone and excise the fibrous tissue between them. With a fine saw cut from one fragment a thin triangular slice of bone after freshening the opposite end. The slice of bone is hinged by the periosteum at the other end of the saw line. The triangular wedge of bone is now turned downward and its apex is sutured with chromic gut to the raw bone surface below or it can be pushed into the medulla. As much as 2 in. of bone may be replaced by this method. The periosteum is the permanent pedicle.

B. OLLIER'S OPERATION PAR GLISSEMENT. Freshen the end of each fragment and remove the fibrous tissue. From the upper end cut a triangular piece of bone with periosteum on it, but do not separate this portion of bone from its connections with the soft parts. Slide this piece of bone downward and suture it to the end of the lower fragment.

C. OLLIER'S OPERATION OF IMPLANTATION. This is only suitable when one of 2 parallel bones is the site of a defect. The sides of the ends of the fragments are obliquely vivified opposite the bone from which the transplant is to be taken. These surfaces make 2 sides of a triangle. From the opposite healthy bone a triangular piece of bone is cut which retains its connections with the soft parts. The graft is turned and implanted into the defect, where it is sutured.

D. MULLER'S TWO OPERATIONS.—The first is made by turning the flap, which consists of skin, periosteum and bone, the pedicle being permanent. The ends of the fragments are exposed by a vertical incision which projects upward and downward, covering 1½ in. on the surfaces of each fragment. Remove all scar tissue interposed and freshen the ends and sides of the bone with a chisel. On the surface of the upper fragment outline a tongue-shaped flap, cutting through the periosteum with the knife. The pedicle, consisting of skin, is off to one side. With a chisel introduced through the upper flap incision cut a slice of bone corresponding to the skin incision. Rotate this flap so that it bridges the osseous defect and fasten the bone in the flap to the raw surfaces of the fragments with chromic gut. Undermine the edges of the upper defect so as to bring them together or close it by Thiersch's grafts.

The second method by Muller is one in which the twisting of the pedicle is avoided. Make a V-shaped incision, the open part of the V being about 2 in. below the end of the lower fragment and projecting upward the same distance in front of the upper fragment. Carry the incision through the periosteum below and raise a slice of bone with the chisel from in front of the lower fragment. Elevate the flap, expose the defect between the fragments, remove the fibrous tissue, vivify with the chisel the ends of the bones and the front of the upper fragment. Carry the incision upward through the skin only on the surface of the upper fragment and loosen this part of the flap. Draw the flaps up until the bone in the flap bridges the defect between the upper and lower fragments. Suture the bone in this position. Carry the incision upward until the redundant portion of the upper part of the flap can thus be smoothed out. Undermine the edges of the lower defect and bring them together or Thiersch graft them. This operation has given Muller, Sprengel, and von Eiselsberg splendid results.

These operations are not of frequent applicability. If the defect be over 4 or 5 cm. they will be impossible. An objection which strikes me is the increased liability to infection, owing to the Thiersch grafts, or to tension of the sides of the defect as well as to the small raw surfaces which are liable to be left at the sides.

Vulpius has cut a transplant from one of the fragments with a pedicle solely of periosteum, situated very near the pseudarthrosis. He then turns the graft 190° around on this pedicle and fixes it to the other fragment. A musculo-aponeurotic flap has been used, obtaining the transplant from a neighboring bone. Codivilla has transplanted a graft taken from the iliac crest upon the femur, twisted about a pedicle taken from the gluteus maximus; and upon the humerus a graft taken from the external border of the scapula, nourished by a part of the external rotators of the shoulder. Bardenheuer in two cases has transplanted the spine of the scapula upon a pseudarthrosis of the humerus. These procedures seem complicated and unnecessary. In defects in the lower jaw a flap, consisting of skin, periosteum and a section from the clavicle, may be dissected up with a skin pedicle and fitted into the vivified defect in the lower jaw.

HAHN'S OR HUNTINGTON'S OPERATION.—This is suited to patients in whom there has been an extensive loss of tibia but whose fibula remains intact. Through an appropriate incision (curved across the leg at the level of the upper fragment), expose the under surface of the upper fragment and vivify it. Cut the fibula off at this level and insert its end into the under surface of the tibial upper fragment, where it is fixed. Six months later, a second operation is done. Expose and vivify the upper surface of the lower fragment of the tibia. Divide the fibula at about the same level and unite its lower end to the fresh surface of the tibia. In some cases both operations have been done at a single sitting.

A graft increases in size according to the demands put upon it. This is seen in the case of the above transplanted fibula which eventually increased in size to that of the tibia.

Bardenheuer in a defect in the humerus made a tongue flap on chest, and subperiosteally resected a rib, which was left attached to flap, which was reflected into defect. Division of the bridges occurred in 2 months. Good union resulted.

4. **Transplantation Combined with Arthroplasty.** Rovsing excised a sarcoma from the upper end of the humerus and implanted a segment of the fibula. He excised the diseased bone from the humerus together with its periosteum and muscular attachments. He then exposed the upper end of the fibula through a longitudinal incision, retracting the uninjured external popliteal nerve out of the way. The superior tibiofibula articulation was opened and the ligaments divided. The fibula was then mobilized for a distance of 3 cm. longer than the segment of humerus which was removed by cutting the muscles arising from it, leaving a muscular sheath, about 1 cm. thick, attached to it. The lower end of the fibula fragment was sharpened with a chisel and forced into the medullary cavity of the remaining diaphysis of the humerus. The remains of the articular capsule of the shoulder joint were sutured about the upper end of the fibula and the soft parts of the arm were sewn to the muscular tissue left attached to the transplanted fibula.

Walther and also De Gouvea each resected the inferior extremity of the radius for sarcoma. Into the resulting defects each transplanted the superior extremity of the fibula with its periosteum, the head of which was placed in contact with the carpus. Intermedullary fixation of upper end of graft. Result in each case was splendid.

5. **Transplantation of Periosteal Flaps (Codivilla's Operation).** Codivilla, after freshening the ends of the bone, unites them with a wire suture and envelops this suture with a free, detached flap of periosteum taken from any convenient bone, taking pains to shave off with the periosteum a thin shell of bone, but Brade used the periosteum alone and obtained a good result. It would seem to the author better to use an absorbable suture such as large chromic gut rather than wire between the bones. The internal surface of the tibia is a good location from which to get the periosteum. A thin slice of bone should be taken with the periosteum and attached to it.

6. **Transplantation for Congenital Absence of Tibia.** Halstead Myers (11) operated as follows: The entire tibia was wanting, but the fibula was intact and in its proper position. The outer half of the joint was incised, opening the articulation between the fibula and femur. The patella ligament, thin and strong, was found to be inserted into the inner side of the fibula well below the head. The external lateral ligament was divided. The head of the fibula was drawn down into a position between the condyles. The patella liga-

ment was shortened and attached to the anterior surface of the fibula. The articular capsule was sutured so as to aid in holding the head of the fibula in its new position. The wound at the knee was closed after which the ankle was opened by a transverse incision, the external malleolus was cut off and the raw end of the fibula was planted onto the upper surface of the astragalus which was freshened by the chisel to receive it. The bones were sutured together. Immobilization. A year after the operation, the patient could flex his leg to 90°, almost fully extend it, and walked about all day.

7. **Transplantation of Dead Bone, Either Decalcified Bone Chips or Large Fragments.**—SENN'S DECALCIFIED BONE CHIPS. PREPARATION OF THE CHIPS.—Remove all periosteum and medullary tissue from the fresh tibia or femur of the ox, divide into longitudinal strips about 1/8 in. wide and immerse in a relatively large quantity of 10 per cent. watery solution of hydrochloric acid which is renewed daily, for from 1 to 2 weeks; then wash thoroughly in water or a weak solution of caustic potash, cut into small chips, soak for 48 hours in 1: 1,000 mercuric bichlorid solution, and remove and store in a saturated solution of iodoform in ether. When about to be used, wrap in aseptic gauze, dissolve out the excess of ether and iodoform with alcohol and put in 1: 2,000 mercuric bichlorid solution until required, when careful drying with iodoform gauze should precede their implantation.

TECHNIC.—Completely fill the cavity or the defect between the ends of bone whose extremities have been previously freshened with the chips, and allow blood to fill up the interstices between the chips. It is claimed that the bone chips strengthen the framework of the blood-clot into which the healthy granulation tissue penetrates, while the iodoform disseminates through the blood clot and thus inhibits bacterial activity.

TRANSPLANTATION OF LARGE FRAGMENTS OF DEAD BONE.—This method has given some notable successes.

Kausch, after removing the upper end of the tibia for sarcoma, implanted a corresponding portion of the tibia obtained some days previously in the course of an amputation. The implant was deprived of its periosteum and marrow, was carefully boiled and soaked in ether to remove its fat. An amputation 9 months after the transplantation for recurrence of the sarcoma, showed the implant firmly united both to the femur and tibia and enveloped in a newly formed periosteum. Kuttner excised the upper third of the femur for sarcoma and at once implanted a similar portion of the femur obtained from a man who died of coma due to tumor of the brain. The upper end of the femur along with its head was removed under aseptic precautions 11 hours after death and was preserved for 24 hours in salt solution to which some chloroform had been added. Six weeks later the result was promising. Brewer, of New York, removed the entire lower third of the radius with its periosteum for sarcoma. A few days later a suicide was brought into the hospital, where he died. The corresponding radius of this corpse was dissected out, of just sufficient length to fill the defect. This bone was then boiled and kept for several days in sterile salt solution, when the original wound was reopened and the graft was implanted. The soft parts were sutured around it. Union was by primary intention. Several months afterward the transplant showed a moth-eaten appearance as though it were absorbing. One year later the man had a very useful forearm and hand. At the junction of the graft with the old shaft there was some bowing, but union was solid. Röntgenograms showed that the old graft had largely become absorbed but that it had been replaced by new firm bone. The result was very satisfactory.

How many non-successes have followed this method no one can say. Surgeons are not inclined to publish their non-successes, hence the investigator can scarcely arrive at an unprejudiced judgment of the true value of any particular method.

A better method of transplantation is as follows: Walther (17), like Brewer, resected the inferior extremity of the radius for sarcoma. Into the defect he transplanted the superior extremity of the fibula with its periosteum, the head of which was applied on the carpus. Intermedullary fixation of upper end of graft. The result was fine.

De Gouvea (4) performed an exactly similar operation, also with a successful result.

8. **Transplantation of Absorbable or Non-absorbable Foreign Material.**—A. NON-ABSORBABLE MATERIAL. Murphy and numerous German surgeons have implanted into a defect in the lower jaw made for the removal of malignant tumors, a silver wire model with a metal head of the normal size and shape of the mandible. In Murphy's case suppuration occurred around the framework, since it communicated with the mouth, and a profuse discharge was present for 6 weeks, when it ceased entirely. The sinus healed and the framework became completely imbedded. Three years later there was no sinus present and the function was good. Because of their vascularity and resistance to infection, the mouth and face offer the best field for the use of foreign material. In other parts of the body, sinuses may form which will persist, requiring the removal of the foreign material.

B. ABSORBABLE FOREIGN MATERIALS such as ivory, magnesium plates, tubes, or columns have their uses in but a few situations in the body and can usually be replaced to advantage by living bone grafts taken from the same patient who is to be grafted.

Primrose implanted an ivory peg of suitable size and shape into a phalanx removed for a central enchondroma. Fourteen weeks later a röntgenogram showed the peg partially absorbed but surrounded by a satisfactory amount of bone. Possibly a better method would be to remove a phalanx from the patient's toe with its periosteum and transplant that, or else take a small piece from the tibial crest with its periosteum.

9. **Transplantation of Joints.**—See Joints, pages 443, 444.

OPERATIONS ABOUT THE KNEE-JOINT

CHARLES E. FARR

General Considerations.—Any operation in or about the knee-joint requires a technic far superior to that ordinarily considered necessary for the general run of major operations. The joint is so large, so complex, and has so many communicating recesses that any departure from the most rigid aseptic technic is an invitation to almost certain disaster. Moreover, the resisting power of all joints to infection is notoriously slight and this is, perhaps, especially true of the knee. One may insult the peritoneum with considerable impunity, adding trauma to infecting organisms in moderate amounts without any untoward results in many instances, but this is not true of the knee or other major joints. The following considerations may, therefore, be held axiomatic for operations in this situation:

(1) Never operate on the knee-joint except for well-marked indications.

(2) Never operate in the presence of any infectious process, whether local or not, regardless of its magnitude, unless the indications are extremely urgent.

(3) Never operate unless there is the most perfect command of all aseptic conditions, including skilled assistants.

(4) In general, operations should not be performed immediately following an injury; they should not be treated as emergency cases but several days at least should be allowed for reaction to become established.

Anatomical Points to Be Considered.—The anatomy of the knee-joint is too complex to be considered at any length in this article, but a few of the more important points will be touched upon. The bony landmarks of the joint are easily made out and need not be detailed. In stout subjects it is convenient to remember that the upper border of the tibia is on a line with the lower end of the patella when the knee is partly flexed. Flexion and extension occur largely between the femur and the semilunar cartilages, while rotation takes place between the cartilages and the tibia. In full extension no rotation is possible, in mid-flexion rotation is at its greatest.

The blood and nerve supply of the joint are extensive, but no important vessels or nerves will be injured by incisions in front of the lateral ligaments. These latter, especially the internal, are very important guides in the work, and with the crucials form the great stabilizers of the joint. They must never be divided except under the gravest necessity. Their position will be at once recognized when the capsular ligament is exposed.

The internal ligaments of the knee are of the utmost importance to the surgeon, as they are the most prolific source of internal derangements of the joint. This is

especially true of the semilunar cartilages, particularly the internal, which, being firmly attached to the internal lateral ligament, is quite liable to injury by twisting or rotation of the joint, just as the internal lateral ligament is far more liable to injury than the external.

The size, shape, and consistency of the cartilages, as well as the ligamentum mucosum and the ligamenta alaria, must be observed in many normal joints before one is really competent to pass upon their pathological changes.

Although the main cavity of the knee-joint is easily exposed by any one of the numerous incisions advocated, there are a number of communicating sacs or bursæ which are not so readily explored. These must be borne in mind when the conditions in the main joint cavity do not seem to correspond to the symptoms. Loose foreign bodies, bits of cartilage, etc., may easily slip into one of these recesses and escape notice. A knowledge of their existence and their topography will usually obviate any serious error, although it is by no means easy in all instances to locate and remove the source of the trouble.

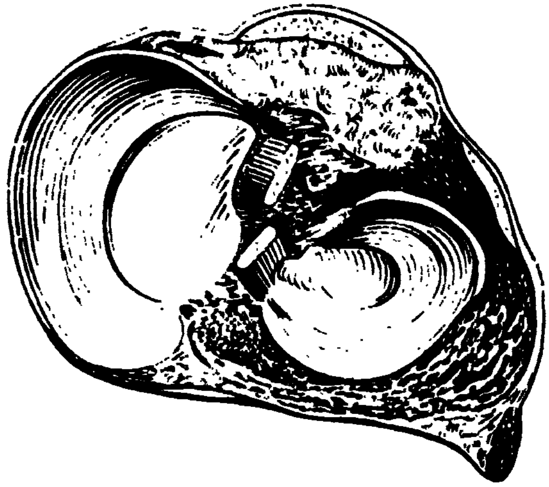

FIG. 47.—UPPER END OF RIGHT TIBIA SHOWING SEMILUNAR CARTILAGES.

Preparation of the Patient.—Especial pains must be taken to see that the patient is in the best possible general and local condition before operation is undertaken, particularly as to any possible source of infection. Prolonged rest of the joint is advisable if any signs of synovitis of an acute type are present. The skin should be in perfect condition and every care must be taken that no abrasions shall occur during the course of the preparation. The method of local preparation will vary with the operator, but it cannot be too rigid in all its details. The method preferred by me is as follows: Lather and shave the thigh, knee and leg with the utmost care, rinse with sterile water, dry, scrub with 95 per cent. alcohol, paint with one coat of half strength tincture of iodin, allow this to dry, and cover with sterile gauze. The following day, on the operating table, the field should be thoroughly scrubbed with equal parts of carbonate of soda and chlorid of lime, moistened and applied with a piece of soft gauze. Wash with sterile water, dry, apply 95 per cent. alcohol, and follow with one coat of full strength tincture of iodin. Allow to dry for 3 minutes before draping.

The method of preliminary injection of the joint with antiseptic and more or less irritating solutions to produce an aseptic reaction of the synovial membrane, introduced and practiced by Murphy, is interesting and perhaps valuable. Murphy's method is as follows: Prepare a 2 per cent. solution of formalin in glycerin and allow it to ripen for 24 hours. Of this solution, inject from 5 to 20 c. c., according to the joint capacity, and place the joint at rest for several days until the reaction has subsided for the most part. This injection may be repeated if necessary, the theory being that in this manner a "coffer-damming" of the lymph-spaces is produced. Although Murphy's reported results are exceptionally good, the method is still in the experimental stage and has not been generally adopted.

The use of the Esmarch bandage and the tourniquet in operations on and in the knee-joint is strongly advocated by many surgeons, but there would seem to be no real need for it in any ordinary case. Hemorrhage is not generally to be feared and, even if it were, it would seem to be better practice to control it by the usual means than to trust to the bandage. The danger of thrombosis and embolism must surely be greater after the application of the Esmarch.

FLOATING BODIES

Indications for Operation.—Floating bodies in the knee-joint, whether true foreign bodies or isolated fragments of tissue, pedunculated or free, such as fatty or fibrous tabs, hypertrophied synovial membrane or bits of cartilage, generally cause a low-grade, non-infectious synovitis, with pain, effusion, locking of the joint, and a feeling of weakness and insecurity. Added to these may be stiffness, muscle spasm, atrophy, creaking in the joint, and finally local tenderness over the body itself. If these symptoms, or a major portion of them, be present in a given case, the indications for operation may be considered fairly strong, provided deforming arthritis can be reasonably excluded. The two conditions may co-exist, and it then becomes a matter for careful judgment as to whether the gain to be expected from operation will outweigh the risk. In general it will not, but in exceptional cases, especially when the floating body is suspected of causing or at least markedly aggravating the arthritis, operation may furnish considerable relief.

Contra-indications.—Operation should not be advocated in the aged, the feeble, or in those suffering from multiple joint disease. Any infectious process in any part of the body is a strong contra-indication to operation.

Preliminary Examination.—As a preliminary to operation on the knee-joint for floating or loose bodies of any sort, an attempt must be made to determine, as far as possible, the nature and position of the body, its relations to the joint structures, and its usual range of motion. Much can be learned from a careful history and thorough physical examination, but the X-ray is of the greatest assistance in many cases, particularly when the body is of sufficient density to cast a shadow, and in all cases to determine the amount of damage the joint has sustained. Lateral views of the joint in full extension and full flexion, and anteroposterior views in extension are of great value. Opaque bodies, such as needles, bullets, and the like, may be very accurately located by means of screens with numbered squares or by the use of stereoscopic plates. Unfortunately too much reliance may not be placed on them as the body is quite apt to shift its position before operation is attempted. For such cases the ideal arrangement is a fluoroscopic attachment to the operating table itself, so that the body may be located at the exact moment of incision and removed under the guidance of the eye. The method of fixing the body by means of a sterile pin or needle thrust through the skin before the operation is very useful in suitable cases.

Methods of Operating.- It is generally accepted now by the great majority of surgeons that the operative procedure is much facilitated by keeping the knee flexed to the right-angled position, the method of Jones. This is accomplished by allowing the leg to drop over the end of the table. The field is scrubbed in this position and draped with towels or sheets fastened by clips or sutures in such a manner that they cannot slip. A good plan is to lay a whole towel or sheet over the field and make the incision through it, clamping the cut edges to the skin incision. In this way all movement of the drapings over the operative wound is avoided. If this is not done, one may make the skin incision before the field is entirely draped and then clamp towels, or, better yet, thick washcloths, to the skin edges.

The surgeon's hands, although it goes without saying that they have been cleaned with exceptional care and are covered with new, whole, and unquestionably sterile gloves, must never touch the inside of the wound, the sponges that enter the wound, the sutures, needles, or the distal end of any instrument that is to enter the wound. For this reason, if for no other, rather long instruments of heavy build are advocated. Hemostats which crush the tissues and thus require the use of few if any ligatures are useful. No special instruments are needed for this work other than the regular dissecting set, a pair of long, narrow retractors and a slender-bladed knife or scissors for work within the joint. A bullet forceps will prove useful at times or the ordinary curved dressing forceps may be used. Instruments and sponges must be kept covered until the moment of use. Needless to say, assistants, nurses, and spectators near the wound should be as careful in their respective positions as the operator himself. Much talking, even with the use of face masks, is not conducive to aseptic healing.

The incision depends upon the amount of exploration that is to be done but is usually a curved one on either side of the patella, vertical in direction, at first parallel to the patella and ½ in. from its border until the tibial margin is passed, when it curves sharply backward for a short distance, to the region of the lateral ligaments. A 3- or 4-in. incision is usually sufficient for the ordinary exploration, but there is no objection to a much longer one if need be. For very extensive cases or for those in which the body is not readily located, it is far better to make a second incision on the opposite side of the patella than to traumatize the joint structures by forcible retraction. Only rarely in cases of this sort will it be necessary or justifiable to resort to the transverse incision through the patella tendon to obtain a wide view of the joint.

Once the skin incision is completed, the scalpel should be discarded and a fresh one used for the rest of the dissection. The subcutaneous fat and the muscular aponeurosis are divided carefully in the line of the skin incision, exposing the capsule of the joint. All bleeding points are now clamped with the crushing forceps, which are allowed to remain in position and act as retractors as well. The wound being now perfectly dry, the capsule is seized with toothed forceps and incised for about 2 in. in the same line as the skin incision. Great care should be taken at each stage of the operation to make clean-cut incisions, allowing no rough or slipshod work to leave tabs of tissue or ragged edges to necrose and predispose to infection.

With the wound edges widely retracted and with the aid of a good light, a careful and systematic search of the joint and its accessory cavities is begun. Even if the body is promptly found and removed, the whole joint should be thoroughly examined, nevertheless, for secondary changes, and these must be treated in the best manner the conditions will allow. In general, if the lesion is not of long standing, the joint will be found in a fairly good condition with the exception of a moderate congestion, and this will need no treatment, but in the long-standing cases there is apt to be considerable erosion of the cartilages and even of the bones. The ligamentum mucosum and the ligamenta alaria are particularly liable to injury from the long-continued joint irritation, resulting frequently in hypertrophy of the synovial fringes. Any bulbous or polypoid masses should be removed with the scissors or a sharp scalpel. The bleeding is usually negligible, but if necessary the pedicle may be crushed with a heavy clamp. The use of ligatures should be avoided as far as possible. Around the circumference of the joint and its anterior aspect a careful search is to be made for fatty or fibrous polypoid masses protruding from the synovial membrane. These may be removed freely with the scissors and the bases touched with the actual cautery if any bleeding ensues.

Erosions of the joint surfaces are common in the advanced cases and an attempt may be made to smooth off the roughened areas with the curet or a small flat file. A light application of the cautery to these areas can do no harm and may be of considerable benefit. Bits of loosened cartilage, osteophytes, etc., should be removed freely and an attempt made to render the joint surfaces as smooth as possible. By flexing and rotating the leg upon the thigh, a fairly complete view of the joint may be obtained, especially with the bilateral incision. A final irrigation with saline, paying especial attention to the communicating pockets, is useful in bringing to light small bits of tissue which have been overlooked or even an unsuspected foreign body which has slipped temporarily out of sight. If necessary, these pockets may be slit open freely to admit of a more complete exploration.

In cases where considerable raw surfaces are left something may be gained by a liberal coating of sterile petrolatum, but too much should not be allowed to remain in the joint for fear of setting up an irritation with resulting effusion. The toilet of the joint should be carefully performed as no drainage is permissible. Closure of the wound is effected by a continuous suture of fine plain or chromic gut for the capsule, interrupted sutures of the same material for the aponeurosis, and interrupted silkworm-gut or horsehair for the skin. A liberal dressing of dry sterile gauze or, if preferred, carbolized gauze, is applied and the leg smoothly bandaged from the toes to the groin. The leg and thigh are then immobilized in a plaster case or Stimson molded plaster splint in a position just short of complete extension. The leg should be kept elevated on pillows for the first week.

After-treatment.—The after-treatment in these cases is of the utmost importance. The wound should be dressed on the eighth day, the sutures removed, and light massage administered. The Stimson splint is here of great advantage, as it allows frequent treatments without disturbing the position of the leg and without the trouble of cutting down a cast. Baking of the limb and massage, especially of the atrophied quadriceps, should be practiced daily to aid in the absorption of exudate, but passive motion should not be tried until about the end of the second week. Active motion may be allowed at the end of the third or fourth week, depending on the severity of the operation and the amount of reaction. Weight-bearing is permissible at about this time, provided the joint was not badly disintegrated at the time of the operation. The application of a well-fitting knee cap with lateral irons is a useful procedure, especially in the deforming arthritis cases. Persistence in the baking, massage, and passive motion over a long period of time is essential to success in all but the very early cases. Regulation of the diet, bathing, moderate outdoor exercise and attention to the emunctories are as essential to good results in surgical as in medical cases and should by no means be neglected.

Results.—The results of the operation depend almost entirely on the condition of the joint and on the age and general condition of the patient. Too much must not be expected from any operation in the cases showing advanced disintegration of the joint, nor in the aged, nor in those with a well-marked tendency to arthritic changes elsewhere. In young, vigorous subjects with sound organs and no tendency to deforming arthritis, the results are usually quite perfect.

Dangers.—There are no especial dangers to the operation except that of infection. A painful weak knee may result from operating on poorly selected cases or from neglect of the after-treatment. Partial or complete ankylosis of the joint is to be feared only in advanced arthritic cases. Incomplete removal of the offending bodies will, of course, result in a more or less imperfect cure of the symptoms. Infection of the joint is a most serious condition. All sutures must be removed at once, the wound opened widely, a counter incision made on the opposite side of the patella if none is present, and the joint thoroughly irrigated with a weak antiseptic or a saline solution. No drains should be inserted into the joint, as they only tend to irritate it and produce adhesions. For the milder infections this treatment will suffice, daily irrigations being practiced until the discharge is serous in character, but in the more severe infections the joint must be laid wide open by a generous transverse incision through the patella tendon, connecting the 2 lateral incisions and allowing the patella flap to be reflected upward onto the thigh. The knee should then be put in full flexion and the crucial ligaments cut if deemed necessary for free exposure of the joint cavity. This method will relieve all but the most severe cases of sepsis, and these are hopeless from the beginning. If recovery ensues, a stiff joint is to be expected but fortunately does not always occur. Secondary suture of the tendon and the skin flap, after the sepsis has subsided, with prolonged after-care, is necessary to obtain any sort of function. An arthroplasty or resection may be indicated in certain cases.

RUPTURED MENISCUS

Indications for Operation.—Operation for ruptured meniscus should only be considered in the recurrent cases of locking of the joint, when reasonable attempts at conservative treatment have been unavailing, or when, in recurrent cases, there is a distinct tendency to irritation of the joint. If effusion occurs or if there is a beginning dry synovitis with creaking and crackling, evidencing an early stage of disintegration of the joint, operation is strongly indicated before irreparable damage is done. Young, strong, vigorous adults, especially athletes and laborers, are particularly liable to the lesion and at the same time are by far the most favorable subjects for operation. In acute cases operation is never indicated, while even in the milder recurrent cases without effusion or marked irritation of the joint the risk of the operation about balances the gain to be expected. The selection of cases suitable for conservative treatment, without running grave risk of disintegration of the joint, is a matter of no mean surgical discrimination. In general, the best course in the doubtful cases is to wait but to watch the joint most carefully.

Method of Operation.—The method of operation now practically in universal use is to expose the joint freely, remove the injured cartilage, and effect the repair of other injured or diseased structures in such manner as may be indicated at the time. Any attempt at repair or suture of the detached meniscus is worse than useless in the great majority of cases. The curved vertical incision of Jones is the one most commonly used and gives ample exposure for the general run of cases.

No special instruments are needed outside the regular dissecting set, with the addition of a pair of long, slender retractors and a long thin-bladed scalpel or slender pair of scissors for removing the cartilage.

The preparation of the field of operation must be carried out most scrupulously in every detail, as in every operation involving the opening of the knee-joint. Special pains must be taken that the open wound is never contaminated by contact with anything that has touched the skin. The drapings must be fastened to the skin in such a way that they cannot possibly slide. New sterile rubber gloves should be worn after the hands have received the most thorough and conscientious cleansing. A face mask completely covering the mouth and nose should be used, not only by the operator, but by his assistants and nurses. Needles, sutures, gauze, and instruments which are to enter the wound must be kept covered until the moment of use and then only handled with long forceps. Even the gloved hand must not be trusted for this purpose. Only those who are able and willing to master such an exacting technic should operate in these cases. The Esmarch bandage and tourniquet, although used by many, are unnecessary in operations of this nature.

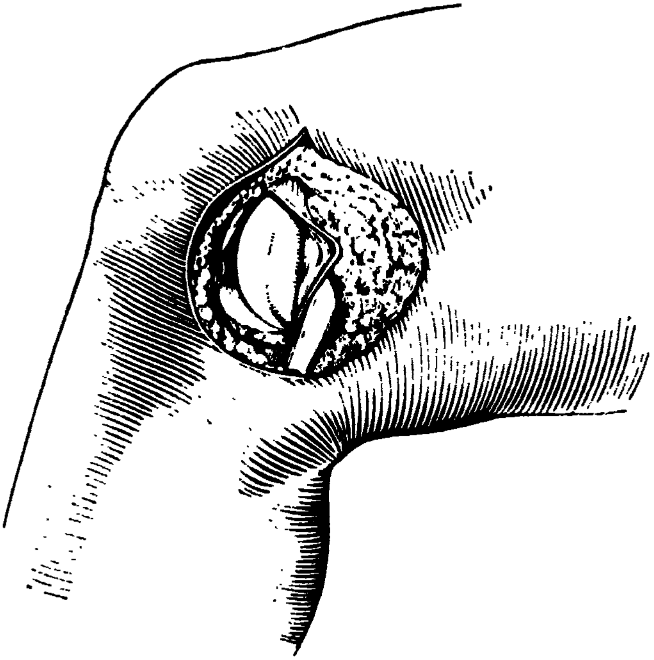

FIG. 48.—INCISION FOR EXPOSURE OF INTERNAL SEMILUNAR CARTILAGE.

With the knee flexed to a right angle and the leg hanging free over the end of the table, the usual 3- or 4-in. vertical incision is made, parallel to the lateral border of the patella and about an inch from it. As the lower border of the patella is passed and the upper end of the tibia approached, the incision is curved sharply backward for ½ in. or more. In the great majority of cases the incision will be made on the inner aspect of the joint, as nearly all of the loosened cartilages are on this side, but, of course, if the symptoms point to trouble in the outer meniscus, the incision is to be made in a corresponding manner on the outer side of the patella. If both cartilages are involved, it will be necessary to make 2 incisions to obtain reasonable access to the joint structures without undue retraction.

This incision is carried in the same plane through skin, fat, muscular aponeurosis, and subaponeurotic fat in one clean sweep, until the joint capsule is exposed. All bleeding is stopped by crushing clamps and the wound made perfectly dry before the capsule itself is attacked. Seizing the capsule with toothed forceps and using a fresh scalpel, a clean incision is made for about 2 in. in the line of the skin incision, extending backward toward but not into the lateral ligament. Any excess of synovial fluid is allowed to escape and the joint is then examined most carefully for evidence of injury or disease. By alternately flexing and extending the leg on the thigh, with internal rotation carried to the extreme, the whole inner half of the joint can be quite satisfactorily examined by sight. The meniscus is usually found more or less bent or rolled on itself, twisted, frayed, or otherwise deformed. If the injury is at all extensive, any attempt at conservative treatment is inadvisable and the entire detached portion of the cartilage should be removed freely with the aid of a thin, sharp knife or a pair of sharp-pointed curved scissors. Note the degree of detachment of the cartilage carefully and go wide of it. Never pull on the cartilage, as this is sure to result in loosening more of it. Bleeding is usually very slight and can safely be ignored, but, if deemed necessary, the actual cautery may be lightly applied. The joint cavity is then to be washed free of clots and debris, and the other lesions attended to as seems indicated.

Closure of the incision in the capsule is to be effected with a continuous suture of fine chromic gut without allowance for a drainage opening. The muscular aponeurosis is closed with a few interrupted sutures of the same material, and the skin with interrupted silkworm-gut or horsehair. No drains of any sort are allowable, not even skin drains. A large dry dressing of sterile gauze is applied, and the leg and thigh smoothly bandaged, using considerable pressure to prevent any effusion into the joint. With the leg in slight flexion, a tin gutter splint or a posterior molded plaster splint is applied, and the leg kept elevated on pillows for the first 2 days, with sand-bags at the sides.

After-treatment.—Baking, massage, and passive motion should be instituted as soon as the joint reaction has begun to subside and should be persisted in for many weeks. Particular attention must be given to the more or less atrophied extensor group of muscles. Active motion may be allowed after the first 10 days and weight-bearing after about 4 weeks, if the synovitis has subsided. Nothing is to be gained by ill-advised haste in the use of the joint. Rest is as essential to complete recovery here as in any other form of synovitis. After 4 weeks the splints may be discarded, but in the cases with marked disintegration of the joint a knee support with lateral irons is indicated.

Results.—The results of operation in well-selected cases are brilliant indeed, the return to normal being nearly or quite complete in the vast majority. If the joint has been allowed to disintegrate to any great extent before operation, the results are correspondingly poorer. Infection is the only danger to be feared. A weak or stiff knee may result from operation in poorly selected cases, from neglect of after-treatment, or from infection. Recurrence of symptoms is not unknown and is due to incomplete removal of the offending cartilage or to the presence of a detached meniscus on the opposite side.

RUPTURED CRUCIAL LIGAMENTS

Indications.—Rupture of the crucial ligaments of the knee is one of the rarest forms of injury to that joint and results only from very severe degrees of trauma. The indications for operation are clear once the diagnosis is established. The only contra-indications are those which hold against any major operation.

Method of Operation.—The technic of preparation of the field, position, draping, etc., is as for other operations involving the joint. The incision must be a very generous one and is best made in the form of a transverse shallow curve, convexity down. The patella tendon is divided with the joint capsule or, if preferred, the tuberosity of the tibia with the tendon attached may be elevated with the chisel or the patella itself divided with the saw. A free exposure is absolutely essential to good work in this restricted field. As usual, all bleeding must be stopped before the joint is opened.

With the patella flap turned upward and the knee fully flexed, a careful survey of the joint is made to determine the extent of the injury. By sliding the tibia backward and forward on the femur, a very good view can be had of the ends of the crucials and the spine of the tibia. Usually all that is then necessary is to freshen the ends of the ligaments and suture them securely in place with heavy chromic gut, kangaroo tendon, or silk. If the ends of the ruptured ligaments are much frayed or are too short, it will be necessary to lengthen them by a simple plastic, such as partial division at the base. In suturing, a mattress stitch should be used, if possible, to prevent tearing out. A rather small needle with a large eye must be used, and considerable ingenuity is required to pass the sutures in the confined space. Mr. Lane's cleft-palate needle holder with a short, strong, and rather straight needle will be found very serviceable. The sutures should not be tied until all are passed.

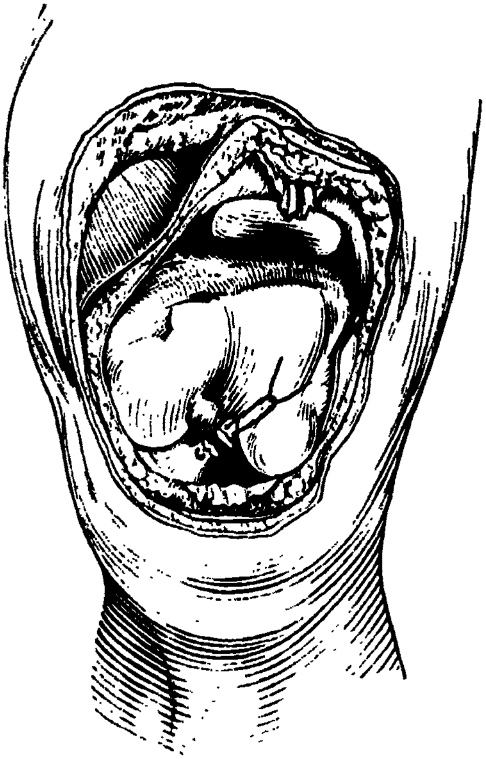

Fig. 49.—Suture of Ruptured Crucial Ligaments.

If, as occasionally happens, the tibial spine is found avulsed, it may be pegged in position by means of a small wire nail.

After the repair is completed, any concomitant injuries should receive the necessary attention and the joint be closed without drainage. If the patella has been divided, it should be sutured as for fracture, the joint capsule being closed with fine continuous sutures of chromic gut and the skin with interrupted silkworm-gut or horsehair. If the tibial tuberosity has been separated, it must be nailed in place with fine wire brads.

After-treatment.—The after-treatment is as for any other operation involving the opening of the joint, but immobilization should be more prolonged and a restraining apparatus should be worn for many months to prevent excessive motion of the joint, particularly hyperextension. The results of operation in this condition are said to be very good, but too few cases have been operated upon to warrant drawing conclusions.

RUPTURED LATERAL EXPANSIONS

Indications.—In any fracture of the patella, particularly in those caused by indirect violence, there is a very marked tendency for the tear to extend outward into the lateral expansions of the aponeurosis of the knee and into the lateral portions of the capsular ligament. The indications for operation constitute an essential part of the indications for operation for the fracture of the patella and have the same limitations. No operation should be considered in the very old, the very feeble, or in those suffering from advanced arthritic changes. Any infectious process in any part of the body is a strong contra-indication to operation. In cases complicated by extensive injuries to other parts of the body operation should be postponed until all danger of shock is passed and, in general, it is always better to wait a few days after the injury for a certain amount of reaction to take place.

Preparation of the patient and the field of operation must be most assiduously carried out in every detail according to the most rigid technic of joint surgery. The instruments required are the same as for suture of the patella.

Method of Operation.—The incision commonly used for exposure of the tears in the lateral expansions is the curved transverse, convexity downward and somewhat below the line of fracture in the patella. This is open to the objection that it weakens the joint slightly and that in case of refracture the joint is perhaps more likely to be exposed. The great advantage of the incision is, of course, the ease with which the operative intervention is carried out. Refracture is rather exceptional and compounding still more so. The old vertical incision must be a very generous one to permit adequate exposure of the tears without undue retraction.

The operative closure of the lateral tears is very simple, once the exposure is obtained and the patella sutured. The fringes of the ligament or tendon in which the patella develops and within which the fracture occurs are always to be lifted out from between the fragments, trimmed, and sutured. If these are followed laterally, it will be found that the tear does not cease at the lateral margin of the patella, but extends for a variable distance into the aponeurosis and capsular ligament. The edges of the tear may be freshened if thought necessary, taking care not to remove good tissue. The flaps should then be overlapped slightly and sutured with interrupted mattress stitches of fine kangaroo tendon or chromic gut. A very fine running suture of the same may be used to secure a more perfect coaptation of the edges. The remainder of the operation is as for the patella fracture.

After-treatment.—After-treatment is very important in these cases. A Stimson posterior molded plaster splint is the best means of immobilization, and this should be continued for about 6 weeks. From the fifth day, however, the dressing may be removed for massage and baking. A few degrees of passive motion may be tried at the end of 3 weeks, but nothing is to be gained by early active motion. Weight-bearing may be allowed at any time as soon as the acute reaction has subsided.

Results.—The results in practically all cases where a good aseptic technic is employed are perfect or nearly so. Even with only fibrous union in the patella, the results are good provided the lateral tears have been properly sutured. The dangers are those of any major operation in which a large joint is opened.

TUBERCULOSIS OF THE PATELLA

Indications.—Isolated tuberculosis of the patella is a rather rare lesion but is occasionally met with and requires operative treatment. The diagnosis is rarely if ever made except at operation. The indications for operation are clear if a swelling is present in or upon the patella of a chronic nature and not involving the knee-joint or the prepatella bursa. With the aid of the X-ray in anteroposterior and lateral views, the former taken from behind forward, the amount of bone involvement can be fairly well determined in advance and the proper treatment adopted. If the disease is simply a part of a joint tuberculosis, the treatment is entirely different from that of isolated disease and becomes only a part of a joint resection. The contra-indications to operation are the same as for any simple operative procedure in a tuberculous subject. In other words, the operative treatment is only indicated in those cases in which the local focus is the principal one in the body and in which there is a fair chance of a radical removal of the disease.

Method of Operation.—The instruments needed for the operation are the usual dissecting set, with the addition of a good bone curet, gouge, chisel and mallet, periosteal elevator, and large burr.

If the disease, as determined by clinical signs and the X-ray, is of any extent, a generous curved transverse incision, convexity downward, should be used. The arms of the incision should extend well upward onto the thigh and the middle of the curve should be nearly over the tuberosity of the tibia. Every aseptic precaution should be observed, as the danger of opening the joint is considerable. The flap of skin and subcutaneous tissue is reflected well upward onto the thigh, exposing the patella tendon and the lateral aponeurosis freely. A vertical incision is then made down to the patella and the aponeurotic structures divided and turned outward to the border of the patella, on either side, which is a rather difficult procedure, as the tissues are very adherent.

Once the patella is freely exposed, a thin, wide chisel is used to remove the outer layer of bone until the extent of the involvement can be determined. The remainder of the operation may be performed with the gouge, curet, or burr, according to the operator's choice. The whole patella may be enucleated if the involvement is extensive, but it is better to preserve the posterior shell with the joint cartilage if possible, and for this reason the use of the power-driven burr is strongly advocated, as a clean removal may be carried out with much less danger of injury to the joint. The cavity in the patella tendon should then be sterilized with pure carbolic acid (phenol) followed by alcohol, dried and packed with gauze until the next steps of the operation are completed.

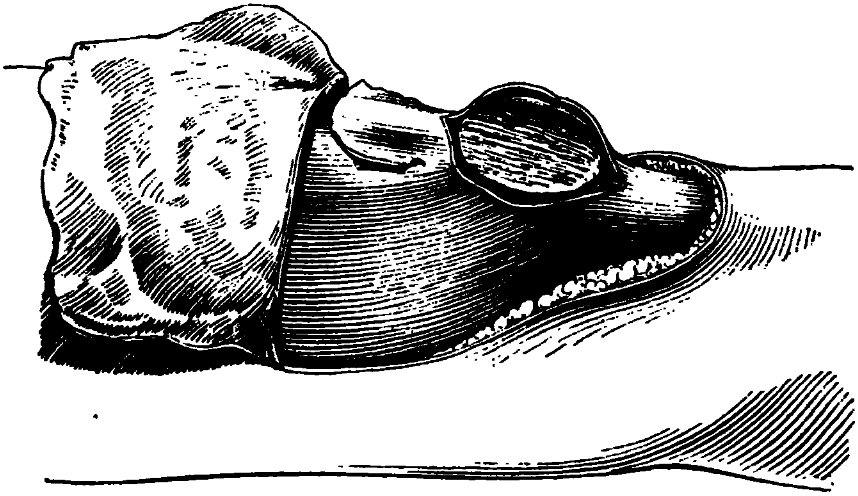

Fig. 50.—Murphy's Plastic Operation for Tuberculosis of Patella.

There are 3 methods of closing the gap in the patella tendon. The cavity may be simply packed with gauze and allowed to heal by granulation; a flap of muscle and aponeurotic structures may be turned down from above; or lateral incisions may be made and flaps slid in to meet in the midline. The first plan is the simplest, but will result in a tedious convalescence and possibly in a weak knee from stretching of the scar. It is only to be recommended when local or general conditions are such that a plastic is contra-indicated. The second plan is the one recommended by Murphy. It is not difficult to perform, but the blood supply of the flap is poor and necrosis may occur. It necessitates a wide dissection of the flaps. The third plan is simple and easy to carry out. It will not weaken the joint if the freeing incisions are made in front of the lateral ligaments. It must be borne in mind that in Murphy's method the nerve supply of the muscle flap is destroyed and that the flap must inevitably atrophy and disappear, being replaced by fat and fibrous tissue.

If the tuberculosis of the patella is only a part of a general involvement of the joint, the indications are for a wide removal of the adjacent involved tissues. No attempt at conservative treatment is to be thought of. If the bone is only slightly involved, a part of it may possibly be preserved and used in one of the various plastics for completing the ankylosis of the knee, but in general true conservatism demands a radical removal of the entire patella.

Results.—The danger of the operation is comparatively slight provided the joint is not opened. The results are fairly good in this class of cases, depending upon the degree of bone involvement and upon the possibility of radical removal of the diseased focus. A strong, useful knee may be expected in the early cases and in those in which the knee-joint is not involved.

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SURGICAL THERAPEUSIS OF THE FACE AND SCALP

CHAPTER VIII

SURGICAL THERAPEUSIS OF THE FACE AND SCALP

WILLIAM S. THOMAS

SURGICAL ANATOMY OF THE SCALP

The scalp (see Fig. 1) consists of five layers covering the cranium as follows:

(1) Skin,
(2) Subcutaneous fatty tissue,
(3) Occipitofrontalis muscle and its aponeurosis,
(4) Subaponeurotic connective tissue,
(5) Pericranium or periosteum of the skull.

The skin over the scalp is the thickest upon the body and is closely attached to the underlying muscles so that they move together. This close attachment prevents the occurrence of swelling during inflammations of the scalp except to slight degrees. This close attachment of skin to muscle, together with the scant supply of fat in the intervening fascia, also accounts for the great scarcity of lipomata here and the slight degree to which the scalp participates in obesity.

The rich supply of sebaceous glands in the skin of the scalp accounts for the common occurrence of wens in the locality.

The thin broad layer of the occipitofrontalis muscle and its tendinous aponeurosis reach over nearly the whole scalp. In front it extends to the eyebrows, at the sides nearly as low as the zygoma and behind, it terminates at the superior curved line of the occiput.

After extensive abscesses under the muscle have been thoroughly incised and drained and are healing, it is necessary to keep the sliding scalp at rest upon the cranium by strapping and bandages.

The loose character of the connective tissue between the muscle and the immovable periosteum allows of considerable movement of the outer three layers upon the skull. In machinery accidents, where the scalp is torn from the skull, it is in this layer that the separation occurs. (Layer 4, Fig. 1.)

The scalp is especially well nourished by blood-vessels, many of which course through the skin itself, so that necrotic conditions are rare here, even in cases of severe lacerations or other injuries.

The pericranium may be easily stripped up from the skull except at the sutures, but even if this occurs as the result of injury, necrosis of the underlying bone rarely follows. On the other hand, once a portion of the skull is lost, there is but little hope of new bone being formed to repair the defect, even though the pericranium has been left intact.

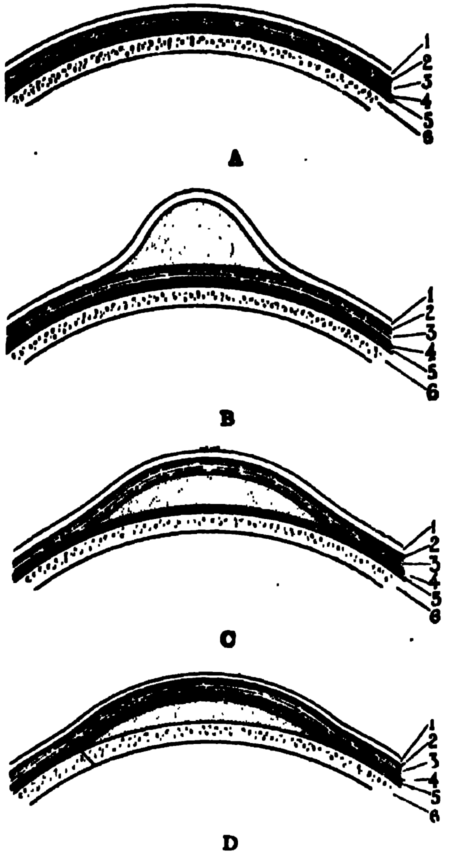

FIG. 1.—DIAGRAM SHOWING LAYERS OF SCALP AND SITES OF ABSCESS OR HEMATOMA.

A, B, C, and D—1, Skin; 2, subcutaneous fascia; 3, aponeurosis of the occipitofrontalis muscle; 4, loose subaponeurotic fascia; 5, pericranium or periosteum covering the skull; 6, skull. B—Subcutaneous abscess or hematoma. C—Subaponeurotic abscess or hematoma. D—Subperiosteal abscess or hematoma.

The two layers of tissue, viz., numbers 2 and 4 (Fig. 1), are of especial surgical interest since it is in their loose meshes that the extravasated blood of hematomata and the pus of infections lodge.

In the temporal region the thick body of the temporal muscle forms a pad filling the temporal fossa. This pad is covered by a firm layer of fascia securely attached above to the temporal ridge on the temporal and parietal bones and below to the zygomatic arch. Over this fascia is a layer of fatty subcutaneous fascia.

Abscesses in the fossa are confined by the dense fascial layer and tend to point downward into the maxillary regions and even into the neck.

Hematomas or collections of blood in the scalp, if occurring in the subcutaneous fascia will be small, on account of the density of the tissue, but those in the loose layer between the aponeurosis of the muscle and the periostium may be large, but the blood-vessels in this cellular tissue are not abundant enough to make it a common experience to see hemorrhages raising a considerable part of the scalp. (See Fig. 1.)

Hemorrhages between the periosteum and cranial bones do not cross the suture lines. (See Fig. 1.) They are rare except among new-born infants whose heads have been exposed to undue pressure during labor (encephalocele).

SURGICAL ANATOMY OF THE FACE

(*Exclusive of Eye, Nose, Mouth, Nerves, and Salivary Glands*)

The skin of the face (see Fig. 2) is thin and connected by a delicate fascia to the underlying structures. To these characteristics are due the fact that abscesses of the face point and discharge externally before they attain great

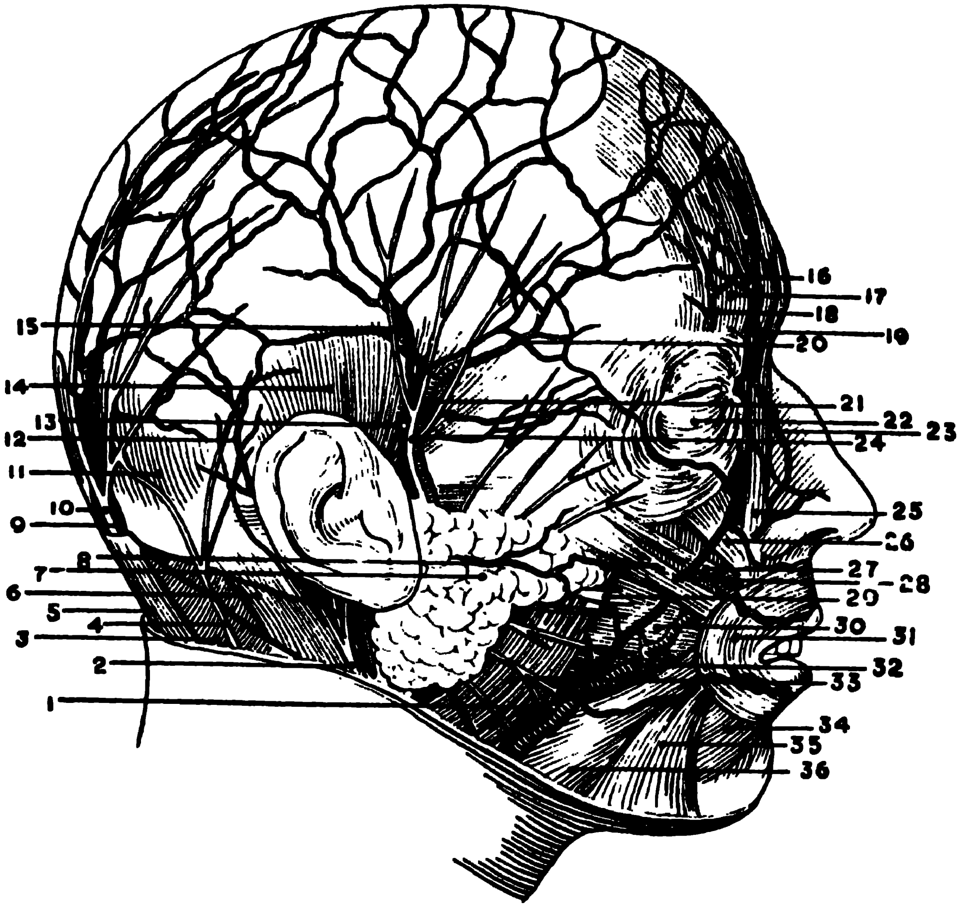

Fig. 2.—Anatomy of Face and Scalp.

1—Facial vein; 2—posterior auricular nerve; 3—splenius capitis muscle; 4—minor occipital nerve; 5—trapezius muscle; 6—sternomastoid muscle; 7—parotid gland; 8—transverse facial artery; 9—occipital artery; 10—great occipital nerve; 11—occipital fibers of occipitofrontalis muscle; 12—posterior auricular artery; 13—temporal vein; 14—attolens aurem muscle; 15—parietal branch of temporal artery; 16—frontal artery and nerve; 17—frontal fibers of occipitofrontalis muscle; 18—supraorbital nerve and artery; 19—frontal vein; 20—frontal branch of temporal artery; 21—temporal artery; 22—orbicularis oculi muscle; 23—angular artery; 24—auriculotemporal nerve; 25—levator labii superioris; alæque nasi muscle; 26—levator labii superioris muscle; 27—zygomaticus minor muscle; 28—zygomaticus major muscle; 29—parotid duct; 30—buccinator muscle; 31—orbicularis oris muscle; 32—facial artery; 33—masseter muscle; 34—depressor labii inferioris muscle; 35—depressor anguli oris muscle; 36—platysma myoides muscle.

size. The skin of the face is well supplied with sweat glands and sebaceous follicles as is evidenced by the common occurrence there of acne.

The connective tissue of the face is lax enough to permit of the spread in it of serous exudates in dropsical conditions or pus in cellular infections. This laxity is especially marked about the orbit. The skin about the symphysis of the chin is adherent to the bone in somewhat the same manner as that of the scalp is to the cranium.

As in the case of the scalp, so in those parts of the face where the skin covers prominent bones as in the chin or cheek, a blow with a blunt instrument often causes a clean incised wound.

Although there is a plentiful supply of subcutaneous fat in the face, yet fatty tumors here are rare. The thickness of the tissues of the cheeks and lips favors the lodgment of foreign bodies; and the softness of these parts permits the rare form of necrosis in young children known as cancrum oris or noma to destroy considerable areas rapidly.

The vascularity and mobility of the facial tissues permit of good results in extensive plastic operations, and it is doubtless this same vascularity which accounts for the frequency of nevi upon the face, and again is instrumental in the notable readiness of wounds here to heal promptly.

The pulsation of the facial artery can best be located by the palpating finger at the lower border of the jaw as the vessel passes up in front of the masseter muscle. At this point its accompanying vein is close to it but elsewhere the two vessels are separated by a considerable interval. (See Fig. 9.)

The facial vein has deep connections which anastomose with the cavernous sinus, the internal jugular, and even with the intracranial veins. These connections explain the fact that carbuncles of the face occasionally cause the fatal complication of septic thrombosis of the cerebral sinuses.

The malar bone is especially firm and rests upon the more delicate superior maxilla, into which it may be driven without being broken itself.

The superior maxilla is fragile but vascular and is readily repaired. Foreign bodies may be driven into its cavity, the antrum of Highmore. The bone is a favorite site for phosphorous necrosis.

The periosteum of the upper jaw is like that of the skull in not being apt to form new bone after it has been destroyed. In this respect it differs notably from the periosteum of the lower jaw where a productive periostitis is often seen after disease or injury.

PROCEDURES AND APPLIANCES USED IN SURGICAL THERAPEUSIS OF THE FACE AND SCALP

CARBON DIOXID SNOW

Carbon dioxid snow is a valuable agent for destroying abnormal tissues upon the surface of the body and is especially applicable to the treatment of certain lesions upon the face, such as superficial epitheliomata, lupus, moles, and nevi, because of the freedom from consequent scarring.

This substance is readily obtained from surgical instrument makers in small steel cylinders or in the large containers used in charging soda water, and is not expensive. Apparatuses are sold for the purpose of fashioning the snow collected at the outlet of the tank into shapes suitable for use in treating skin lesions. Such an apparatus is adjusted to the vent of the tank and when allowed to escape into it, the carbonic acid gas condenses into a cylindrical mold forming a pencil of compact snow ready for contact with the lesion to be treated.

It is possible, however, to make satisfactory therapeutic use of the snow with no other apparatus than the tank, some twine, and a piece of chamois skin a foot or more in diameter. The leather is doubled in several thicknesses and applied over the gas vent so as to make a small bag with its mouth tied securely in place with twine. While the snow is being collected in the bag the outlet of the cylinder must be at its lowest part. When the outlet valve of the tank is open, cautiously at first and then more freely, there comes a rush of escaping gas which immediately condenses into hard dry snow within the chamois bag. When the bag contains enough snow, as will be made evident by pinching it between the fingers, the valve is closed and the whole removed. The snow is manipulated into the form of a ball or pencil by the hands of the operator while it is still within the leather. At all times the operator's hands must be protected from prolonged contact with the snow in order to avoid frost-bite.

A neatly formed stick of the snow for therapeutic use may be collected in a mold of blotting-paper rolled in several thicknesses around a pencil as a form, which is then removed and the roll of paper reinforced by being wrapped with narrow turns of adhesive plaster so that it will not burst under the pressure of the escaping gas. This mold is closed at the end by pinching it and folding it back, holding it firmly with more turns of the plaster.

Such an improvised mold will require an outlet nozzle on the tank over which it may be fastened.

The temperature of the snow as it is received from the tank (79° below zero) is low enough to cause it to be destructive to superficial ulcerations about the face when pressed firmly against them for ½ to 1½ minutes, but for larger thicker lesions such as moles, angiomata, etc., it may be necessary to lower the temperature of the snow still further by adding a little ether to it. The resulting slushy snow is packed into as hard a mass as possible by manipulation in the chamois leather or with whatever apparatus is used.

I have applied the snow conveniently by means of simple hard rubber syringes. The nozzle of such a syringe is cut off, the piston drawn back and snow packed tightly into the barrel. The open end with its snow presenting is then pressed firmly against the lesion. Enough additional pressure is made with the forefinger upon the handle to keep the evaporating snow firmly in contact with the lesion for the proper period of time.

The parts should be cleansed before applying the snow since the latter is not an antiseptic. Refrigeration lowers the vitality and resistance to infection of the parts treated.

While the snow is being applied the skin is put on the stretch if necessary to give it a plane firm surface. The snow should overlap the surrounding healthy skin as little as possible. The snow and ether mixture will require less time to produce a given effect than will the hard dry snow. From 20 to 90 seconds are the usual extremes of time used for a snow application. If the lesion treated by immediately over bone, caution should be used to avoid an overdose. An ulcer followed by an unsightly scar may follow the application of the snow for too long a time. In large lesions areas of ½ in. in diameter are treated at each sitting.

The pain from the application is trifling and is seldom complained of. The immediate objective effect is a marked blanching of the hard frozen area. Its surface is depressed below the level of the surrounding skin by the pressure of the snow. When thawed the treated area begins within a few minutes to show slight redness and swelling. A bleb as after a second degree burn may appear later but there is less pain. The treated area is kept clean and protected by a light dressing. If the lesion is superficial and the snow applied for less than 30 seconds no bleb is likely to appear. In from 10 days to 2 weeks healing should be complete. The skin is smooth and somewhat reddened for a time but it gradually becomes pale and the scar is soft and does not contract.

The application of carbon dioxid snow is not suited to patients with very poor circulation or with much lowered vitality.

ADHESIVE PLASTER

The modern white non-irritating adhesive plaster is a great improvement over the older preparations and is especially useful in the treatment of various surgical conditions of the scalp and face. Its especial uses are to retain dressings in place and to take the place of skin sutures. For the latter purpose narrow strips are applied across the line of incision while the edges are held in contact. The technic is too obvious to require description here but it may not be amiss to mention the fact that if ready sterilized strips are not available the plaster may be sterilized by exposing it in a closed receptacle for 8 hours or more to the fumes of formaldehyd. A ready means of sterilization is to pass the strips just before use through an alcohol flame rapidly but repeatedly so as to kill all bacteria upon it but yet not burn it.

COLLODION

Flexible collodion is applied over sutured wounds which are partly healed or have no tendency to ooze. Its impervious nature makes it desirable in the protection of wounds from outside infection, but this quality also contraindicates its use where it might prevent the free drainage of any wound secretions. It may be painted over gauze or over a thin layer of cotton wadding in covering small wounds. The cotton or gauze is cut to proper shape and size to cover the wound and the collodion is painted on over it and on the surrounding skin for a little distance. It dries quickly and adheres to the skin and to the dressing in an impervious semitransparent layer. A neat covering for small wounds is made by cutting one or two layers of chiffon to a proper size and painting the collodion over this.

SUBCUTICULAR SUTURE

The hidden continuous suture is well adapted to the repair of incised wounds of the face where it is important to avoid conspicuous scars. It leaves no needle puncture marks save at the end of the wound and secures a neat approximation of the edges when properly done.

The needle may be straight or curved and the suture material is preferably of silk or linen.

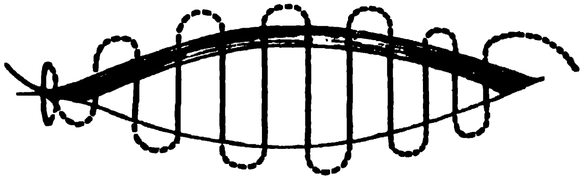

FIG. 3.—DIAGRAM OF SUBCUTICULAR SUTURE.

The operator begins the suture at one end of the wound as with the ordinary continuous type, but all stitches after the first one, instead of penetrating the surface of the skin, pass in and out of the wound edges in the true skin beneath the cuticle from side to side as shown in Figure 3. When crossing from one side of the wound to the other the needle enters the skin directly opposite to the point of last emergence or possibly a little back of this. The sutures are left loose and the wound gaping until its length has been traversed, when each crossing of the thread is caught successively in a thumb forceps and pulled taut so that the wound is neatly closed. While the last crossing is still held in the forceps the finish is made in the manner of an ordinary suture, puncturing the skin as was done at the beginning. A refinement of the method which obviates any puncturing of the skin surface is accomplished by fastening each end of the thread to a pledget or little roll of gauze instead of to the skin. (A fine continuous silk suture passed through the skin edges in a skillful manner leaves less scarring than any subcuticular suture and causes no irritation in the face.—EDITOR.)

WET DRESSINGS

A saturated or half strength boric acid solution and a normal salt solution are especially applicable about the face, where stronger antiseptics would harm the organs of special sense, but the best all-around wet dressing here is perhaps Wright's solution of sodium citrate (1 per cent.) and sodium chlorid (2 per cent.). This is bland and not especially antiseptic but it has the great advantage of being diffusive and of preventing the coagulation of discharges or secretions. In this respect it is directly the opposite in action of solutions of mercuric bichlorid which coagulate albumin and are seldom desirable as wet dressings. Alum acetate solution (saturated) is an excellent wet dressing, widely used in superficial infections. If used about the face, especial care should be taken to avoid contact with eyes or mouth.

A wet dressing becomes dry by evaporation in an incredibly short time and the moisture should be frequently replenished. If the dressing is covered with an impervious layer of gutta-percha tissue, oiled paper, or oiled muslin, etc., evaporation will be delayed and rewetting will not be so often required. When such an impervious covering is used, however, care must be taken in supplying fresh moisture that every part of the dressing is saturated.

Once the wet dressing has been thoroughly drenched with a solution of any salt, subsequent wettings may be made with sterile water inasmuch as the salt itself does not evaporate.

The wet dressing is a sheet anchor in many inflammations and never does harm. (Three to 5 per cent. aluminum acetate is the best wet dressing known to me.—EDITOR.)

PICRIC ACID DRESSINGS

A 2 per cent. aqueous solution of picric acid applied as a wet dressing is the best application for burns of the second degree from whatever cause. Stronger solutions are unnecessary and if applied over extensive surfaces will cause constitutional poisoning. Sterile gauze is applied to the lesion and soaked with the picric acid solution. Loss by evaporation is taken care of either by frequently replenishing with water or else and preferably, by covering the dressing under the bandage with an impervious layer, as of oiled paper or rubber tissue. Such a dressing is left in place for a day or two before being replaced unless copious serous oozing requires more frequent changing. Under this dressing for burns, pain subsides, oozing ceases and healing begins in a surprisingly short time.

The yellow staining of the skin by picric solutions is conspicuous and rather persistent and should be anticipated by the surgeon. The aqueous solution will even pass through a rubber glove and stain the surgeon's hands if the contact is long continued.

This permeating power of the solution may be used in treating various superficial inflammations and infections of the skin by painting it on and allowing it to dry.

BIER'S HYPEREMIA OF HEAD AND FACE

The whole head may be rendered hyperemic by a broad ligature about the neck just tight enough to cause a moderate venous stasis of all the parts peripheral to it, without interfering with the carotid circulation. But hyperemia of the head caused by this method is uncomfortable and extends to parts not under treatment, and is seldom used. It is mentioned here in order to remind the reader of its possibilities in the absence of proper apparatus for the usual method of hyperemic treatment.

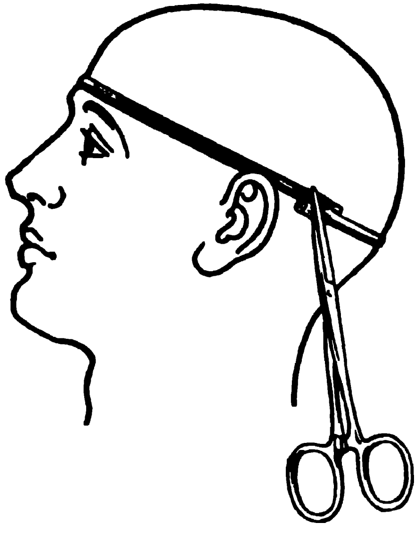

Fig. 4.—Rubber Tube Ligature of Whole Scalp.

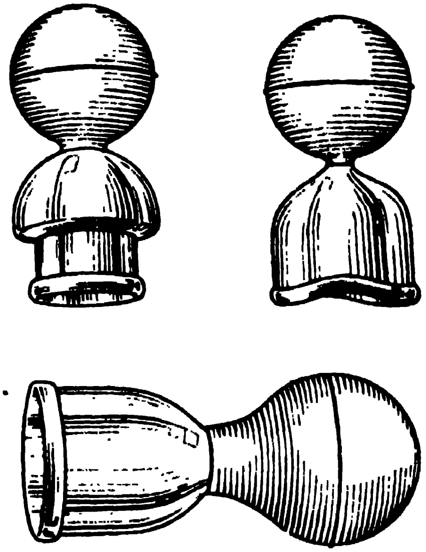

Fig. 5.—Various Forms of Glass Cups with Rubber Suction Bulbs for Application of Bier's Hyperemia.

Scalp.—Ligation of the scalp (see Fig. 4), applied just tightly enough to cause moderate venous stasis only, is a practical means of producing therapeutic hyperemia in the treatment of inflammatory diseases of the vertex where the application of Bier's suction cups is less practicable than on other surfaces.

Face.—Bier's suction cups (see Fig. 5) are applied to the skin of the face and occasionally of the scalp, particularly in cases of furuncle, acne, carbuncle, sinuses, and drained abscesses. They are of many shapes and sizes but those shown in Figure 1 are applicable to most areas about the face. Some cups are shaped so as to hold the discharges of wounds under treatment and to prevent soiling of the rubber bulb. The old-fashioned dry cups with rubber suction bulbs answer for the treatment of small lesions upon the face such as acne pustules and small furuncles but usually have the disadvantage of small size and weak suction power. **The diameter of the cup should always be great enough to include healthy skin about the lesion under treatment.** If the skin is rough and dry and suction is incomplete, vaselin may be applied to the edge of the cup in contact with the skin. To apply it, the bulb is squeezed and the open end of the cup is pressed against the skin. The bulb is then released and atmospheric pressure holds the cup in place while the skin is puffed up into it. If the vacuum is too great, the skin will become cyanotic and discomfort will be complained of. The cup should be applied with the bulb squeezed just enough so that when released the skin will be reddened and raised moderately under it.

In the case of suction hyperemia, as well as with stasis from constriction with a ligature, proper technic requires that the parts under treatment shall be: (1) red, not cyanotic; (2) warm, not cold; (3) comfortable, not painful.

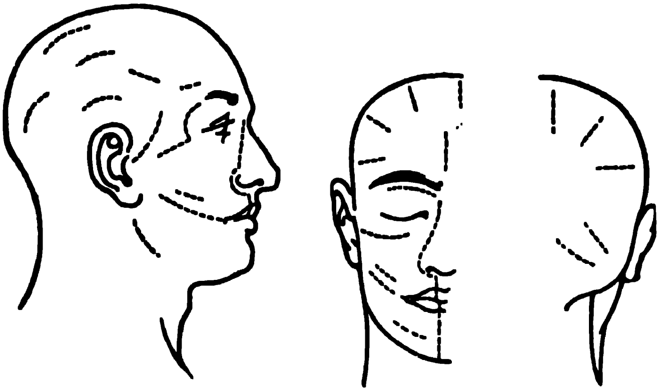

FIG. 6.—KOCHER'S NORMAL INCISION LINES OF FACE AND SCALP.

In the treatment of acute inflammations the suction cup is left in place for from 3 to 5 minutes and then removed until the hyperemia disappears, when it is reapplied in the same manner, thus insuring a fresh supply of blood and phagocytes at the site of the lesion. From 2 to 4 such applications are made at intervals of from 3 to 24 hours.

Every detail of the technic should be rigidly adhered to and the method should not be entrusted to the care of persons other than those who can carry it out properly.

The cups and bulbs are sterilized by boiling.

NORMAL INCISION LINES OF FACE AND SCALP

Kocher has made the surgical world conversant with the work of Karl Langer who in 1861 first demonstrated the existence of lines of cleavage in the skin of the human body.

In all parts of the body, but especially about the face and neck, the appearance of linear cicatrices after simple cutting operations is best if the incisions have been made in the direction of these lines of cleavage. Wound edges after incisions in these so-called "normal lines" fall naturally and neatly together without gaping and require few sutures to hold them in place. If, however, the incisions are made in other directions the wounds gape widely and it is difficult to secure accurate approximation of their edges even with sutures placed closely together. After healing the scar following a normal incision is almost unnoticeable, while one after a cut at right angles to a cleavage line is apt to be more or less permanent. If an incision in the line of skin cleavage is made for the purpose of drainage of an abscess, or to open an area of cellulitis, it will be apt to close prematurely and must be kept open by artificial means, such as a tube or other drain so long as drainage is required. When such a wound heals, however, it will naturally give a better cosmetic result than would one made at right angles to it which would be more easily kept open. (See Fig. 6.)

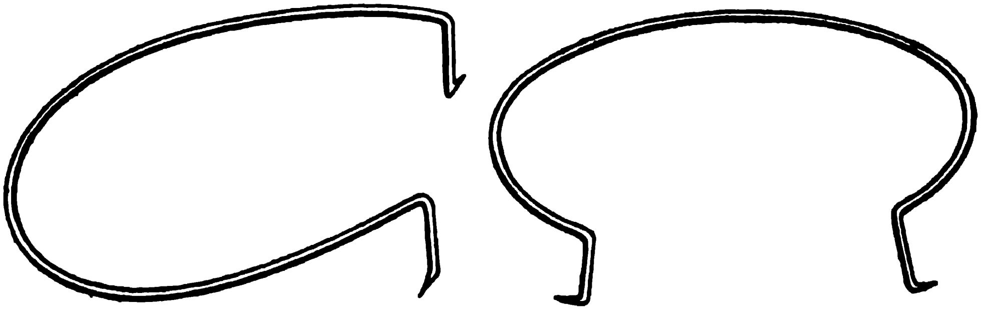

Fig. 7.—Self-holding Retractor.

Incised or lacerated wounds of the hairy scalp are not apt to gape, no matter what their direction, unless they are deep enough to extend through the occipitofrontalis muscle and then only when at right angles to the direction of its fibers.

SELF-HOLDING RETRACTOR

This self-holding retractor devised by me, in 1903, is of use in cutting operations about the face and scalp, especially where assistants may be lacking. It is easily applied, quickly shifted and will stay where it is put. It takes up little room when in use. The circular spring rests flat upon the surface of the skin and the bend of the hook is arranged so as to prevent the circle from rising and getting in the operator's way. The instrument is made of phosphor bronze or German silver wire. The ends of the wire are brought together in the grasp of fingers and thumb. The retracting ends are then put into the wound so that its edges are pulled apart by the spring of the wire. A delicate retractor with a 1¼ in. circle may be used in a small cyst of the face while a long wound may be kept open in its whole length by one or two of the larger sizes with their openings facing each other. (See Fig. 7.)

MICHEL'S SKIN CLAMPS

As a substitute for skin sutures the Michel skin clamp has the advantages of quickness and ease in applying and the avoidance of stitch marks and stitch abscesses. In cases where there is much tension of the sutured skin, or where there is a large cavity to be obliterated, these clamps must be supplemented by deep sutures.

The metal clamp while open and ready for use is held in the grasp of especially designed forceps, with the reserve supply upon a holder or rack from which it is easily removed after being grasped by the applying forceps. While the skin edges are adjusted and held in apposition by toothed forceps or tenacula, or even by the fingers, the clamp is applied across the wound and pinched into a bent position so as to squeeze the wound edges into coaptation. The material is just strong enough to keep its shape until bent straight again by the removing forceps. The tiny point at each end of the clamp penetrates the skin only enough to secure the instrument in place. The clamps are applied at distances of from ¼ to ¾ in. apart according to the character of the wound. If the incision has been made in the line of cleavage of the skin (see Normal Incisions) comparatively few clamps will be needed to secure accurate coaptation of the wounded edges.

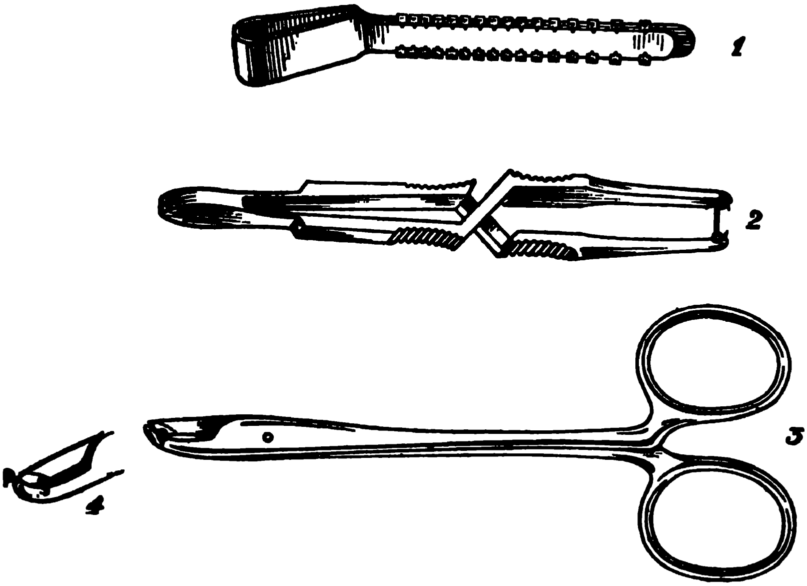

FIG. 8.—MICHEL'S SKIN CLAMPS AND APPARATUS FOR APPLYING AND REMOVING THEM.

1—Rack for holding clamps when not in use; 2—applicator forceps with a skin clamp in its bite for pinching together the edges of a skin wound; 3—removal forceps. The curved jaw is slipped under the bent clamp. When the jaws of the forceps are brought together the clamp is released and removed; 4—straightened clamp held in the bite of removal forceps.

Numerous forms of forceps for applying and removing the little hooks are sold by instrument makers. One of each of these together with a holder is shown in Figure 8. Several of the applying forceps may be used at an operation, an assistant loading one or more while still another is in use by the operator.

LIGATION OF THE FACIAL ARTERY

Ligation of the facial artery is called for at times to control hemorrhage from wounds in it, or as a preliminary step in operations likely to be complicated by hemorrhage such as those for angioma of the face, or malignant growths supplied with blood by it. Its anastomoses are so extensive that when it is divided it must be ligated on the distal as well as on the proximal side of the division.

The pulsations of the artery are most easily felt where it passes upward across the border of the lower jaw in the depression formed by the anterior edge of the masseter muscle, which makes a landmark. At this point the artery is comparatively superficial, being covered only by the skin, superficial fascia, and the thin platysma myoides muscle and still thinner deep fascia. The facial vein accompanies it and usually lies to its outer and posterior side. (See Figs. 2 and 9.)

The 1-inch incision, in order to leave an inconspicuous scar, is made parallel to the border of the jaw (see Normal Incisions) and directly over it, but it is made while the skin is pulled upward from the neck by the fingers of the operator's left hand. This procedure will make the skin wound drop back half an inch or so below the level of the ligature at the completion of the operation. The incision, being over the artery and vein and at right angles to them, is cautiously made. Upward retraction of the upper wound edge is maintained by a broad sharp retractor during the dissection and ligation of the artery. The artery is located by the landmark of the masseter edge and by its own pulsation and is freed from its surrounding fascial attachments and sheath by careful dissection, both sharp and blunt. The ligature holder (usually a probe or blunt hook armed with catgut through an eye near its end) is passed close to the artery from behind forward and then withdrawn, leaving the catgut held in place ready for tying in a square knot. When its ends have been cut off and all bleeding points in the wound checked, the

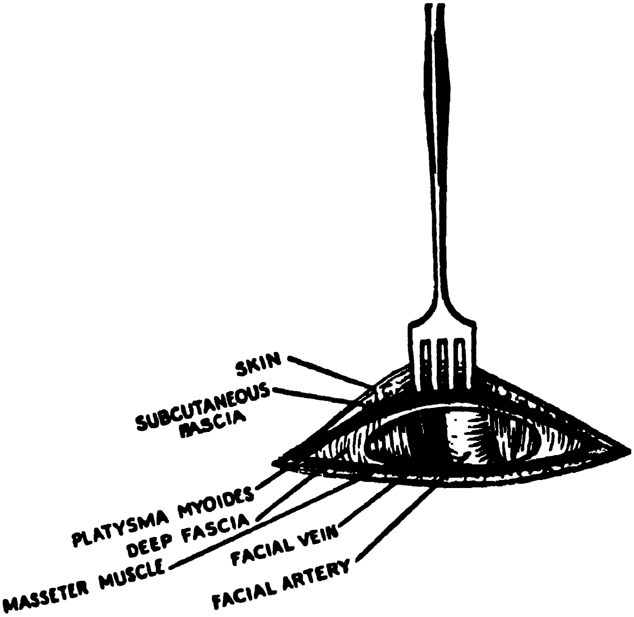

FIG. 9.—RELATIONS OF FACIAL ARTERY FOR LIGATION.

retractor is removed and the line of the skin incision is allowed to return to its natural position below the border of the jaw where it will be more or less hidden. Michel skin clamps (see Michel Skin Clamps) or fine silk sutures repair the wound in the usual manner.

For general directions as to the ligation of arteries the reader is referred to another part of this work.

INJURIES OF THE FACE AND SCALP

SCALP WOUNDS

Contused Wounds.—Contused wounds are of surgical interest when they are complicated by hematoma. (See Hematoma of Face and Scalp.)

Abraded Wounds.—Abraded wounds are sometimes complicated by the presence of dirt or foreign bodies imbedded in the skin. The aims of their treatment are cleanliness and prevention of infection.

The scalp is shaved on and about the wound. If particles of dirt, coal dust, grease, etc., are imbedded in the abraded surface, they should be removed. Simple washing may not suffice in which case the wound is scrubbed with soap, water, and a stiff brush under an anesthetic if necessary. The wound is rinsed with sterile water or saline solution and a protective dressing applied. Sterile strips of rubber tissue laid over the abraded surface will prevent adherence of the dressing and permit the rapid formation of new epithelium. So will a mild antiseptic ointment or one of scarlet red.

Punctured Wounds.—Punctured wounds of the scalp are especially dangerous on account of the liability of their being accompanied by a complicating fracture of the skull. When the history of the injury suggests that the skull has been injured it is essential that the punctured wound shall be enlarged by an exploratory incision. Such an incision should extend through the scalp and will serve the double purpose of clearing up the diagnosis and of permitting a thorough cleansing. (See Fractures of the Skull.)

Lacerated and Incised Wounds.—Lacerated and incised wounds, if through the skin only, do not gape. If they are widely open it is usually because their edges are drawn apart by the fibers of the occipitofrontalis muscle which has been included in the wound.

The essentials in the treatment of lacerated scalp wounds are cleanliness, approximation of the edges, rest and protection. The vicinity of the wound for a distance of an inch away in all directions is cleared by shaving. If, after all blood has been wiped away, careful examination shows no gross dirt or foreign bodies in the wound and the history of the injury does not contraindicate it, the wound and neighboring dry skin may be sufficiently cleansed by the application of tincture of iodin. A 5 per cent. alcoholic tincture is swabbed on freely and will cause but trifling pain. If necessary the parts are cleansed with sterile water, liquid soap, and brush. Hairs, dirt, or any other foreign substances may be picked out of the wound with thumb forceps.

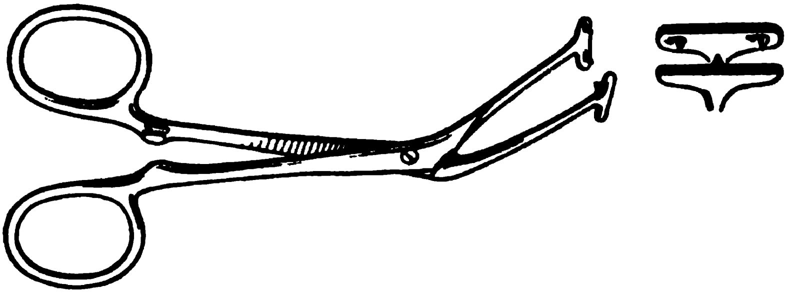

Fig. 10.—Hemostatic Forceps for Wound Edges in Scalp.

Bleeding from lacerated scalp wounds is often considerable owing to the difficulty which the severed vessels have in retracting into the dense tissue of this portion of the body. The first step in checking hemorrhage is thorough retraction of the wound edges so that no part of it is hidden from view. Ordinary artery forceps are not always well adapted to catching bleeding vessels in the dense layers of the scalp. For this purpose special scalp forceps are made (Fig. 10). Small sharp-pointed artery forceps can be pushed into the scalp tissues and will usually suffice. A useful form of retractor for scalp wounds, es-

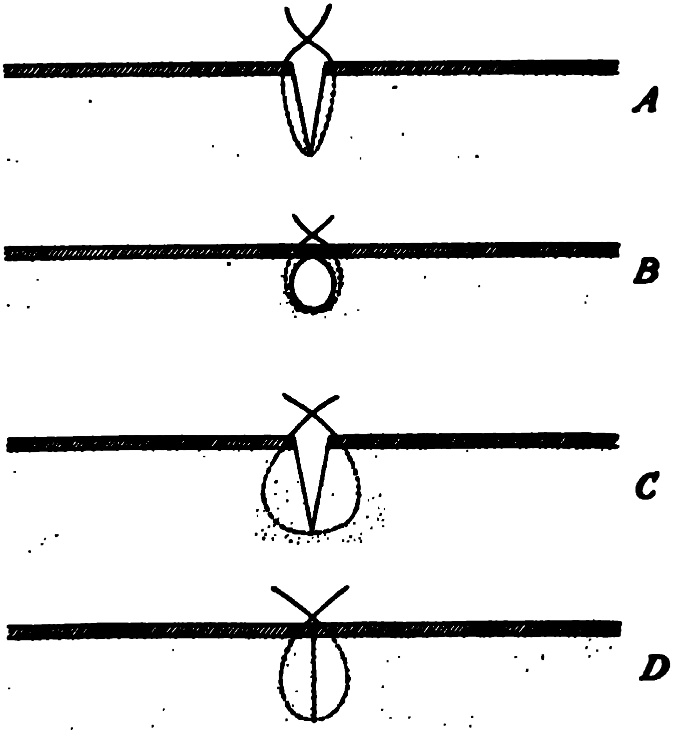

Fig. 11.—Wrong and Right Methods of Applying a Suture in a Superficial Wound.

A—The suture is introduced more or less parallel with the wound surfaces. This results in B, the formation of a cavity under the skin from the purse-string action of the suture when tightened; C—correct manner of applying the skin suture. It is carried well out into the tissues at each side. D—When the suture is tightened the whole depth of the wound is brought together and no cavity is left.

pecially in cases where assistance is lacking, is the self-holding spring instrument shown in Figure 7. Persistent oozing from the surface of the edges of the wound may be checked temporarily by pressure until the wound is ready for suturing when frequent interrupted sutures which include all the layers of the scalp will permanently control hemorrhage. These sutures are applied as shown in Figure 11 so as to make even approximation of the wound surfaces and not cause gaping in the central layers.

A patient with a lacerated scalp wound should be examined carefully for the presence of a possible fracture of the skull. If only the superficial layers of the scalp have been divided at the time of injury and the history or the patient's condition leads to a suspicion that a fracture exists it is the surgeon's duty to complete with the knife the division of the scalp layers down to the skull so that the latter may be examined for the presence of a fracture.

A small impervious drain is left protruding from one point in the line of the sutured wound if its asepsis is doubtful.

Sutures of silk are commonly used in repairing scalp wounds but have no particular advantage over those of silkworm-gut, horsehair, linen or tendon. Interrupted sutures are generally used. In emergency cases where materials are scant it is possible to use the patient's own growing hairs as makeshift sutures. Small wisps of them are caught together on each side of the wound and tied like ordinary sutures over a strip of folded gauze laid along the line of the wound.

The sutured wound is covered with a pad of dry sterile gauze held in place by a bandage for 24 to 48 hours. After this, when oozing has ceased and if the wound be not large the dressing may be held in place by collodion or strips of adhesive. The sutures are removed in 4 or 5 days.

In cases where there is a possibility that the skull is fractured, hexamethylenamin .5 gm. every 4 hours may be given as a prophylactic against infection of the meninges. Laboratory evidence is against the bactericidal value of this drug elsewhere than in acid urine but clinical experience seems to be in its favor and it will do no harm.

HEMATOMA OF SCALP

Hematoma of the scalp is treated with the aim of assisting nature to cause the absorption of the extravasated blood if possible. Failing in this the circumscribed collection of blood is evacuated.

Absorption can occur only in the absence of infection, and to prevent this complication the scalp is sterilized in the vicinity of the tumor. The hair is removed by clipping and shaving and the skin cleansed with warm water, soap, and a brush. If the skin be reasonably clean and dry, sterilization is best effected by painting it with the official tincture of iodin (10 per cent.). After sterilization a pressure bandage is applied over a sterile gauze pad upon the tumor and renewed as soon as it becomes loosened. If this treatment is to succeed the swelling will steadily diminish in size.

If the fluctuating mass shows no diminution in size after several days have elapsed, it may be understood that the lymphatics are unable to carry off its contents and the surgeon will proceed to evacuate it externally.

Operation.—A small incision under local anesthesia is made at or near the periphery of the swelling and the retained blood is allowed to flow out. According to the nature of the cause of the hematoma, the patient's general condition and the length of time which has elapsed since the injury, the character of the tumor's contents will consist of dark liquid blood, clots and stained serum, or disorganized clot and perhaps cholesterin crystals.

Once the blood has been evacuated, a small impervious wick of rolled or folded rubber tissue or several strands of silkworm-gut or horsehair are inserted a short distance into the cavity and left to project upon the scalp under a gauze pressure pad. Daily dressings will show when the cavity is dry and the dressings no longer are stained. Then the drain is removed and the incision is allowed to close. The hair which has grown during the time of treatment may be allowed to remain uncut unless its presence interferes with cleanliness and the necessary manipulations. In the case of a hematoma which continues to increase in size in spite of the application of pressure, it is probable that there is a vessel of some size continuing to bleed and the swelling must be incised across the whole of its greater diameter, preferably under a general anesthetic. The bleeding points along the line of incision are seized with finely pointed hemostatic forceps and the blood all wiped away. The forceps will make convenient retractors with which to open the cavity in the search for any bleeding vessels. All these are grasped and tied with catgut ligatures, and the wound is sutured as described under section on Scalp Wounds. (See Fig. 11.)

If a hematoma becomes infected its contents rapidly become purulent and the treatment will proceed as described under the section on Abscesses of the Scalp. (See Fig. 1.)

WOUNDS OF FACE

The face as well as the scalp is so well supplied with blood-vessels (see Fig. 2) that healing may be expected after even severe laceration or other damage to the soft parts of the face exclusive of the eye. (See Scalp Wounds for general principles.)

Abraded Wounds.—Abraded wounds of the face and of the surrounding skin should be thoroughly cleansed by wiping with gauze and sterile normal saline solution. If they are contaminated with lubricating oil or other grease, turpentine or benzin may be needed to cleanse them thoroughly. Bleeding is usually trifling but if particular attention to it is called for, hot water (110° to 115° F.), hydrogen peroxid, or adrenalin solution, 1:1,000, will be found to be efficient hemostatics on abraded skin.

A wet dressing is the best application. (See Wet Dressings.) It must be kept continually moist for if allowed to dry the dressing will adhere to the wound and when removed will detach the crust of coagulated serum which has been an important aid in the healing process. Where the abrasion is small and superficial a mild antiseptic ointment will be the best application. In order to prevent the grease of the ointment from being absorbed by the gauze dressing it should be applied directly to the wound and covered with an impervious layer as for example, thin gutta-percha tissue, and this in turn is held in place with a gauze pad and bandage. Another excellent dressing in abraded wounds is a plentiful coating of powdered boric acid covered with gutta percha.

Abraded wounds of the face will often be found to contain particles of sand, plaster, coal dust, etc., firmly imbedded. If allowed to remain these may cause permanent marking or disfigurement. To remove them it may be necessary to put the patient under a general anesthetic and scrub the wound with soap, sterile water, and a hand brush. A type of injury of this kind demanding especial mention includes gunpowder marks of the face.

Gunpowder Marks.—The treatment of these will differ according to whether they are seen by the surgeon immediately after the injury or not until healing has occurred.

When the injury is recent the patient is anesthetized and the grains of powder are scrubbed away with a stiff brush, hot water, and sterile liquid soap as described above under Abraded Wounds of the Face.

When the epithelium has grown over the powder grains which have lodged in the skin it will be impossible to remove them without leaving marked scars. The patient or his guardian should be allowed to make the choice between the unsightliness of the powder marks and that of a cicatricial surface. When but a small area of skin is involved it may be excised and a plastic operation done to cover the deficiency. (An aid in the removal of powder grains is a wet dressing of 1:1,000 mercuric chlorid applied for 24 to 48 hours. This sets up an acute dermatitis and many of the powder grains work out of themselves.—Editor.)

Lacerated Wounds.—Lacerated wounds of the face should be examined for the presence of dirt or other foreign bodies and for fracture of the underlying bone. The wound is cleansed as described under Scalp Wounds, bleeding is checked and the wound edges approximated as neatly as possible with sutures (see Fig. 11), strips of sterile adhesive, or Michel clamps (q. v.), always bearing in mind the necessity of securing as good a cosmetic result as possible.

FOREIGN BODIES IN THE TISSUES OF FACE AND SCALP

Foreign bodies in the tissues of the face and scalp, like those elsewhere, must be found before they can be removed. In searching for them the face and scalp usually offer a facility not often present elsewhere. This is a back-ground of bone against which to press the foreign body in the soft parts with the palpating finger. A foreign body in the cheek may be palpated between a finger without and one within the mouth. In recent cases the wound of entrance will sometimes lead the probe directly to the foreign body and is the best of guides.

Transillumination of the mouth, nose, and accessory sinuses will aid in locating a foreign body in the tissues of the face only if it be large and of dense structure.

In the search for a metallic foreign body such as a fragment of lead or sewing needle, the skiagram is an invaluable guide. When it is available no operation for removal should be attempted without its aid unless the object sought for is clearly palpable through the skin. Even if so, the incision is made cautiously and the parts are handled with gentleness in order to avoid pushing the foreign body from its position and losing it.

Operations for the removal of foreign bodies in the tissues are often provokingly difficult. **A free incision, good retraction, and as nearly a bloodless field as possible are essential to success.** The eye is of less assistance than the palpating finger tip in detecting the presence of the object. An infinitesimal amount of tissue or blood will conceal a foreign body from the surgeon's eye, whereas the sense of touch may reveal the object although perhaps covered by a layer of muscle or fascia.

Discomfort, deformity, or the presence or likelihood of infection are the indications for operation. If the foreign substance cause no discomfort or unsightliness and the wound of entrance be healed no operation is called for.

Operation. The usual preparation of the patient's skin is followed by local or general anesthesia. A drop of 1:1,000 adrenalin solution to each gram of the local anesthetic will assist materially in blanching the tissues in the field of operation. With a stereoscopic skiagram, or two skiagrams taken from different angles, if these are available, at hand as guides, the incision is made. This should be made in the normal line (see Normal Incisions) with its center as nearly as possible over that of the foreign body and long enough to admit freely the tip of the operator's palpating finger. If the foreign body be a needle or portion of one, the incision should be made at right angles to its length irrespective of the normal line. The incision is carried through the skin and cautiously through the fascia and as nearly as possible in one continuous plane. If the foreign body lie in the substance of a muscle, the attempt should be made to expose it by a blunt separation of the muscle fibers. It may be necessary to divide the muscle fibers transversely. If this is done upon the face, the divided fibers should afterward be sutured with chromic gut to avoid changing the patient's facial expression.

The ordinary probe is of little use as a searcher. The knife edge is a good detector, but must of course be used with caution as a searcher in the case of metal or glass substances.

Once the foreign body is recognized in the wound, it is immediately grasped with a forceps. If metallic or of wood, the artery forceps are locked upon it, but if of glass or other brittle material a thumb forceps must be used with care. If necessary, the incision may be enlarged enough to permit of the delivery of the object.

If a needle, it is pushed in the direction of its length until one end appears in the wound. This end is grasped with another forceps before the hold of the first one is released and the fragment is removed. If these seemingly trivial details be not attended to, the fragment may be lost or broken during its removal. Cautious cutting, frequent feeling, good retraction, and a bloodless field are the essentials.

I have devised an instrument to aid in finding fragments of metallic substances imbedded in the tissues. (See Fig. 12.) It consists of three needles of steel or iridoplatinum lying parallel and close to each other but nowhere touching and held in a handle. They are connected with electric wires, a dry cell and a telephone receiver in such a way that, when they or any two of them touch a metallic substance, a sound is transmitted to the telephone receiver at the operator's ear. While the use of this instrument by no means obviates the necessity of a skiagram, it affords assistance

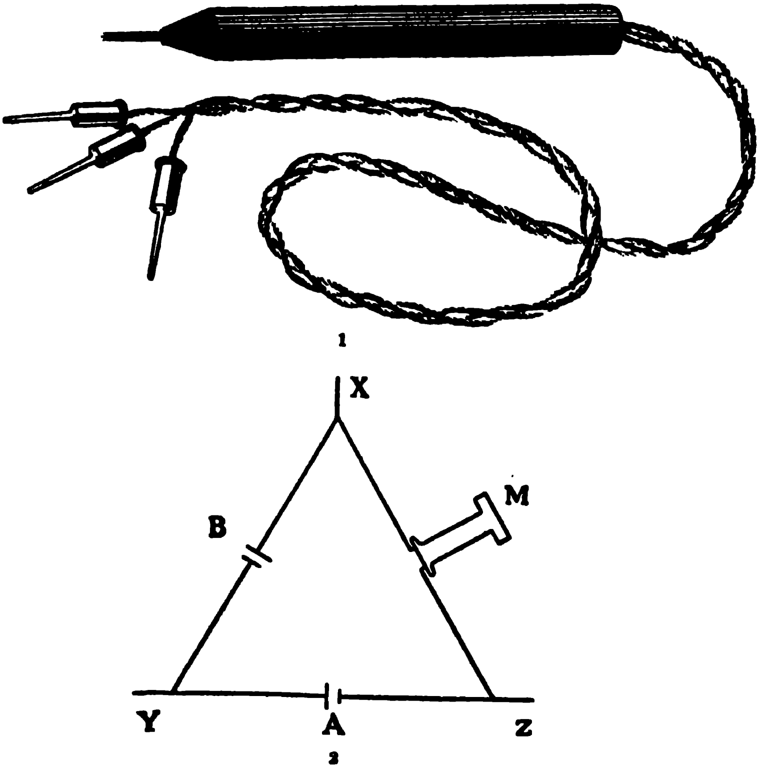

FIG. 12.—TELEPHONIC SEARCHER FOR METALLIC FOREIGN BODIES IN TISSUES.
1—Needles and insulating handle with connecting cords. 2—Plan of wiring searcher. A and B, to dry cell; M, to telephone receiver; X, Y, Z, to needle points.

which is often much needed. The needles are introduced through the incision and into the tissues in the direction in which the metallic foreign body is thought to lie. It is withdrawn and introduced again close by its first path until the neighborhood has been thoroughly searched. The instrument is used in much the same manner as the exploring needle of a syringe, though with a finer adjustment, as it were. Due regard must be paid to the anatomy of the parts.

If the needles touch a metallic body, a sound is heard in the telephone receiver. The switch is turned off, the needles are held carefully in their position and then cut down upon as a guide to the foreign body. The essential difference between this instrument and the older electric bullet probe lies in the fact that it is provided with more than two probing points and that these are sharp and will traverse soft parts of the body independently of the existence of a sinus or wound of entrance. The instrument is made by the Wappler Electric Manufacturing Company of New York.

DISEASES AND INFLAMMATION OF THE FACE AND SCALP

COMEDO

The general principles of the treatment of comedo are similar to those in cases of acne (q. v.) except that the use of vaccines is not called for. The skin is washed at night with tincture of green soap and hot water. The comedoes are removed mechanically by means of a comedo extractor, which is essentially a minute spoon with a hole in the bottom of its cup. When the edges of the hole are pressed firmly about the blackhead it is squeezed out from its bed.

ACNE OF THE FACE

Treatment of acne of the face falls naturally into three classes, viz.:

(1) Systemic,
(2) Local,
(3) Specific.

None of these can be left out of reckoning and, while in rare instances one of them alone may succeed, it is nevertheless due to the patient that his physician shall be conversant with all. A cure will be most readily effected when all three methods are intelligently employed.

Systemic Treatment.—The systemic treatment is based upon the fact that, after age of the patient, the most frequent predisposing causes are digestive disturbances and constipation. These must be rectified. Anemic and debilitated youths and girls who have acne of the face will require iron and arsenic administered so as not to disturb their digestion. Exercise in the open air, sufficient sleep, and a proper diet count for much in the treatment. Sweets and pastry are common contributors to the etiology.

Local Treatment.—BY THE PATIENT.—The face is washed nightly with tincture of green soap and water and rinsed long with water as hot as can be borne. If the skin is irritated by this treatment, it should be repeated at less frequent intervals. After the rinsing, calamine and zinc lotion (calamine, gm.

2.5, zinc oxid, gm. 5, boric acid, gm. 4., glycerin, gm. .5, and water to make gm. 130) is mopped on with a gauze pad for 10 minutes and allowed to remain until the morning, when the face is washed with plain tepid water. If the skin is red and tender, it is anointed in the morning with a small quantity of cold cream.

BY THE SURGEON.—When pustules occur, each one is opened with a finely pointed knife and a Bier's hyperemia suction cup (see Bier's Hyperemia) is applied over the opening for from 1 to 3 minutes. The blood and pus are wiped away with sterile gauze. A pointed stick (match) wetted with 95 per cent. carbolic acid or tincture of iodin is applied to the interior of the little cavity. If the pustules treated are few and small, they may be sufficiently protected after incision by a little mild antiseptic ointment. If considerable in size or number, they should be protected with a light gauze dressing.

Vaccine Treatment.—If the opportunity is present an autogenous vaccine is used and the opsonic index watched while the case is under treatment.

The use of stock vaccines in acne of the face gives good results in a respectable minority of cases. I have had better results in acne from the combined vaccine of Van Cott than from the polyvalent staphylococcus vaccines of several manufacturers. The reader is referred to the article on vaccine treatment in another part of the work.

FURUNCLE OF THE FACE

Furuncle of the face differs from that of other localities in its exposed situation and in the importance of the disfiguring cicatrix which it may leave.

Abortive Treatment.—The great vascularity of the face and consequent opportunity for a natural cure by phagocytosis encourage the surgeon to attempt to cut short the development of a furuncle when localized redness, induration, and papulation give warning of its occurrence.

Citrate of sodium 1 or 2 gm. (15 to 30 grs.) in water, taken by mouth 3 times daily may be prescribed with the purpose of diminishing the coagulability of the blood and thus enabling the serum to carry the phagocytes more readily into the infected area.

Clinical experience has given evidence of the efficacy of yeast administered internally in furuncle and in some other superficial pus-forming infections. It acts supposedly by promoting phagocytosis. Liquid yeast as obtained at a brewery may be given in doses of 120 gm. 3 times daily or 1/3 of a cake of compressed yeast or teaspoonful doses of the dried form of yeast known as cervisine is swallowed 3 times a day.

The skin over the furuncle and in the immediate vicinity is sterilized when dry by painting it with the official tincture of iodin and this may be repeated once daily.

Bier's hyperemia (q. v.) is of great benefit when applied properly during the crescent stage of furuncle. A suction cup large enough for its edges to be everywhere in contact with normal skin is used. Suction sufficient to raise and redden the skin but not sufficient to cause cyanosis or pain is continued for 5 minutes. The cup is then removed and reapplied again after 2 or 3 minutes as before. The hyperemia is repeated 2 or 3 times a day if possible, but it should not be left to the care of any person not experienced in the technic. (See Fig. 5.)

A gauze dressing wet with Wright's solution (see Wet Dressings) is kept continuously applied in the intervals between the application of the suction cup or if this is not feasible a 10 per cent. ointment of ichthyol is laid on under a layer of gutta-percha tissue or other light impermeable material properly secured over the infected area.

When redness, tenderness and induration have disappeared, a last coat of iodin is applied, and then washed off with alcohol, and when the skin is dry collodion is painted on to prevent reinfection.

The method of treatment outlined above is suitable in the case of a furuncle seen at any stage short of the actual formation of a slough or so-called core, and will often cause the subsidence of fairly well-advanced boils.

Treatment when Core Formation Has Occurred.—When necrosis of the subcutaneous tissue occurs it must break down to form pus and be discharged through a wound in the skin before cure is complete. It is the natural impulse of the properly trained surgeon to drain any accumulation of pus by a wide and free incision, but when the wound must be upon the face it is desirable to inflict as little disfigurement as possible. Fortunately, it is possible to drain the average furuncle sufficiently to cause its rapid subsidence, even through a small incision, if this be followed by the application of Bier's hyperemia (q. v.) and wet dressings (q. v.) and provided the surgeon is able to attend to it every day so as to prevent closing of the incision with consequent extension of the infection. The citrate of sodium solution prevents plugging of the outlet of the wound by coagulated discharges and the Bier's suction cup empties the cavity of accumulated pus and assists materially the healing process in the later as well as in the earlier stages of the morbid process. The contents of a furuncle should not be expressed by squeezing. Once drainage is well established the furuncle rapidly heals under the above-described treatment. In the later stage, when suppuration has nearly or quite ceased and other symptoms are diminishing, an antiseptic ointment may be substituted for the wet dressing. This will serve to keep the skin soft and prevent plugging of the sinus or granulating area with dried secretion, a difficulty always to be borne in mind.

CARBUNCLE OF THE FACE AND SCALP

The treatment of carbuncle of the face demands special consideration, on account of its cosmetic aspect. The above statement does not apply, however, to advanced cases in elderly or feeble patients who are already septic when seen by the surgeon. Here practically all considerations should be set aside save the one aim of radical treatment of a dangerous disease. In other words, complete excision of the whole of the infected tissue should be fearlessly undertaken when the carbuncle has advanced to a severe degree and the patient is suffering from constitutional poisoning. The danger signals are not so much to be sought in the extent of area or swelling redness and sloughing of the carbuncle itself, but rather in the patient's general condition. Prostration, rapid or feeble pulse, dry tongue, anorexia—the so-called typhoid state—are indications for immediate and thorough removal of a carbuncle in any patient, but such a chain of symptoms will be found most often in aged or diabetic patients. (See Surgical Anatomy of Face, page 521.) The incision is made expeditiously through normal skin and superficial fascia completely encircling the carbuncle. While an assistant checks bleeding by pressure on hemostatic forceps, the diseased mass, grasped with forceps and pulled upward at the edge, is quickly dissected from its bed of healthy underlying tissue. Important structures must be spared if possible, but **the whole carbuncle must be removed.** Vessel hemorrhage is checked by ligation and general oozing by the application of gauze or towels wrung out of or saturated with hot water (115°-120° F.).

Bleeding should be thoroughly checked before the dressings of gutta-percha tissue, sterile gauze and bandages are applied. Unless there is some good reason forbidding it, the excision should be followed by a Thiersch's skin graft. (It is better and safer to wait until the raw surface is clean and granulating.—EDITOR.) With this procedure in view, it is of course especially essential during the operation for excision of the carbuncle that every endeavor be made to avoid contamination of the wound with infected matter, and that between these two operations, clean surroundings, hands, gloves and instruments be prepared. For a description of Thiersch's skin grafting the reader is referred to another part of this work.

Carbuncles should be incised and drained as soon as possible after the diagnosis has been made. Two free incisions at right angles to each other laying open widely all necrotic areas are the least that should be done in any case. After opening, no scraping should be done, but a Bier's hyperemia cup is applied to aid evacuation of the contents (see Fig. 5) and the supply of fresh blood and phagocytes. The wound is kept open by a loose packing of sterile gauze or impervious (rubber) tissue and a copious wet dressing of potassium citrate and sodium chlorid solution applied. If the carbuncle is of moderate severity and the patient's general condition good, a smear and culture should be made at the time of the incision and if a pure culture can be obtained in a pathological laboratory, an autogenous vaccine should be prepared and used as quickly as possible. The etiologic germ in carbuncle is usually a staphylococcus. If bacteriologic laboratory aid is not available, the surgeon may place some hope in the use of stock preparations of polyvalent staphylococcus vaccines such as are sold by reliable commercial laboratories. For the description of vaccine treatment the reader is referred elsewhere in this work.

Bier's hyperemia when properly used is a valuable aid in the treatment of carbuncle of the face or scalp, and its technic is described elsewhere, but neither vaccine nor hyperemia nor any other method of treatment of carbuncle should supplant free surgical drainage as described above.

One of the most frequent situations for the occurrence of carbuncle is about the hair border and the back of the neck. It is in this very locality that anatomic and cosmetic considerations are most favorable for radical treatment and here there should be no hesitation in excising the affected tissue promptly and completely.

The patient's general condition almost always calls for supporting treatment and the frequency of a concomitant diabetes should be borne in mind.

CELLULITIS OF FACE AND SCALP

There is no essential variation in the treatment of cellulitis of the face or scalp whatever may have been its cause. Whether due to chemical poisoning, streptococcus, staphylococcus or other germs, or whatever the mode of entrance of infection into the tissues has been, the essential principles of treatment are cleanliness, wet dressings, rest, and attention to the patient's general condition.

Nevertheless, in cases of cellulitis of the face cosmetic considerations demand especial efforts to prevent abscess formation with its inevitable drainage and scar. Fortunately, such efforts are favored by the unusually good blood-supply and consequent resistance to infection in this region.

When the infection originates in a tooth socket its extension to the cellular planes of the face is but secondary and the treatment should obviously be directed to the focus in the mouth. The tooth is extracted or the alveolar abscess is drained by incision and the facial inflammation rapidly subsides. Cellulitis of the face from a so-called "ulcerated tooth" will often subside in a few days. When the pain and tenderness have disappeared, the dentist drills through into the root canal, thus establishing drainage of the tooth socket. After the inflammation has ceased he sterilizes the canal through the tooth as well as possible and seals it with a filling.

In those cases of cellulitis of the face which follow infected wounds, insect bites, etc., the usual principles of surgical treatment are to be followed. Signs of the presence of pus such as pitting on pressure with localized redness and tenderness and perhaps fluctuation at one particular point or rapid increase of the inflammation, call imperatively for a cutting operation as described under Abscess of the Face.

In a considerable number of cases of cellulitis of the face or scalp the site of entrance of bacteria is not evident and there are diffuse swelling and tenderness with a moderate amount of pain or redness.

In such cases of diffuse cellulitis of the face, the prompt and continuous application of a wet dressing (see Wet Dressings, page 526) will bring about a steady and reasonably rapid decrease of the symptoms.

Although the use of Bier's hyperemia is of especial value in the treatment of furuncles of the face and scalp and also of drained abscesses in this locality, it is of but little avail in cases of diffuse cellulitis of the face.

As an auxiliary to the wet dressing in these cases the internal administration of yeast deserves mention. (See page 540.)

The patient's general condition should have the surgeon's attention in all infections of the face and scalp. Everything possible should be done to put and keep him in good physical condition in order that his resistance to bacterial invasion may be at its best.

Certain cases of cellulitis of the face and scalp will not do well under any treatment. When the inflammatory symptoms are increasing, the actual signs of pus are not always to be awaited before making an incision for drainage. The time for a cutting operation is often a nice question to determine and the disfigurement of a scar upon the face must be borne in mind. Cosmetic considerations loom large in facial surgery. Once pus manifests its presence, the indication for incision and drainage is clear. (See Abscess of the Face.)

In every case of cellulitis the patient's urine should be examined for glycosuria.

ABSCESS OF THE FACE

When treating an abscess of the face the surgeon should bear in mind that it may be consequent to any one of the following conditions, viz., carbuncle, furuncle, necrosis of bone, dental caries, tuberculous or septic adenitis.

The principles of treatment of abscess of the face are similar to those of the same condition elsewhere, except that especial attention should be paid here to the cosmetic result. To this end if the abscess be opened and drained the incision should be made in the cleavage line of the skin. (See Normal Incision Lines.) An incision made in such a direction will tend to close rapidly and thus interfere with a continuation of the drainage. This tendency must be overcome by the insertion of an impervious drain of ample thickness and length which is not to be removed until healthy granulation is established.

Especially rapid resolution after incision and drainage of abscess of the face is obtained as a rule, if wet dressings of Wright's solution of sodium citrate and sodium chlorid (see Wet Dressings) are applied and alternated with the use of Bier's suction hyperemia. (See Bier's Hyperemia.)

ABSCESS OF THE SCALP

Incision and free drainage are the rule in the treatment of abscess of the scalp as in that of any other situation. Operation should follow diagnosis without delay. Various types of abscess are described below.

Operation.—The scalp should be shaved over an area greater than that of the swelling due to the abscess. The time-honored use of soap and water and turpentine as surgical cleansers of the scalp is justified by their power of removing greasy débris. Sterilization preparatory to incision may be completed by the application of a coat of official tincture of iodin but this is of little use for the purpose unless the skin be dry when it is used.

The abscess cavity is freely opened whatever its nature or location on the scalp. Hemorrhage from the wound edges is controlled by pressure or if from the cut ends of good-sized vessels, these may be seized with finely pointed artery forceps or special scalp forceps. (See Scalp Wounds.) Bleeding points in the scalp edges may also be checked by a ligature of silk introduced through the tissues on a small curved needle. A tube or other impervious drain is introduced or the cavity lightly packed for a day or two with a strip of sterile gauze. Wet dressings of citrate solution (see Wet Dressings) are continuously applied both to allay inflammation and to promote the flow of wound secretions. The dressings should be copious as long as there is considerable discharge, and should be secured by a proper bandage. When the sinus or sinuses are healing nicely the dressing is reduced in size and is retained in place by adhesive strips. The hair should be repeatedly shaved in the vicinity of the sinus for the sake of cleanliness.

Careful investigation should be made at the time of incision of a scalp abscess in order to determine its exact anatomic situation. (See Fig. 1, A.)

Superficial Abscess.– Pus between the skin and occipitofrontalis muscle will usually point externally before burrowing far in the dense upper plane of fascia, and the protuberance or swelling will be rather circumscribed (Fig. 1, B.) A free incision into such a superficial abscess will afford competent drainage if an impervious drain be employed during the continuance of suppuration.

Scalp wounds whether incised or lacerated are not apt to gape, no matter what their direction unless they are deep enough to include the occipitofrontalis muscle, and then only when at a wide angle with the line of its fibers.

This fact should be borne in mind when incising a scalp abscess. (See Normal Incisions.)

Subaponeurotic Abscess.—A pus collection in the loose connective tissue between the muscle and the periosteum spreads quickly and may have floated a large area of the upper scalp layers by the time the surgeon first sees it. (See Fig. 1, C.) Drainage of such an extensive abscess should be made by several incisions at intervals along the most dependent parts of the cavity so that all pus will pass out into the dressings as fast as it is generated.

In order to determine the boundaries of such an abscess a blunt probe is passed into an incision made for the purpose somewhere near the middle of the abscess and is used to locate the limits of the cavity. With the end of the instrument at the lowest limit of the cavity it is cut down upon as a guide and a drainage tube or gauze wick is inserted there. Enough such drainage points are established to prevent any retention of pus. If healing of a large abscess of this type be delayed the whole scalp should be shaved and firmly strapped and bandaged so as to keep the muscle at rest and allow persistent sinuses to close.

Subperiosteal Abscess.—Abscesses between periosteum and skull are seldom seen. The cavity containing pus in such cases does not pass beyond the limits of the sutures in the skull since the pericranium is firmly attached to the bone along these lines. (See Fig. 1, D.) If seen early in patients otherwise healthy, free drainage will usually be followed by healthy granulation and reattachment of the periosteum to the bone without the formation of a sequestrum. For a description of the treatment of necrosis of the skull the reader is referred to another part of this work.

RHUS TOXICODENDRON DERMATITIS OF THE FACE AND SCALP

The treatment of rhus poisoning of the face must be adapted to avoid injuring the eyes, nose, or mouth with lotions, ointments, or powders.

The methods of treatment used for the dermatitis caused by Rhus toxicodendron are legion. Their very number is an indication of their worthlessness. Lotions and salves generally afford temporary relief of the itching and burning, but fail to prevent the spread of the affected area or modify the course of the disease. In fact, alcoholic lotions actually further the extension of the disease since the chemical poison is soluble in alcohol but is not destroyed by it. To rub ointments upon the affected areas also mechanically assists the spread of the dermatitis.

The writer has found the following method successful in curing most cases of rhus poisoning when the proper technic is used. Common laundry soap is moistened and rubbed over the affected area. Where the eyelids are involved, the patient keeps the eyes gently closed while the operator applies the soap in the form of a pencil cut from the cake to allow of precise application. This soap is then rubbed smartly into the skin with sterile gauze wipes or a small swab on a stick in the case of the eyelids, which are then rinsed off with water. Relief after the first smarting is usually almost immediate. If relief does not follow in a few hours, the soap application may be repeated as the initial stage of a more thorough attempt at oxidation of the virus by the application with a brush or swab of a 1 per cent. aqueous solution of potassium permanganate. This is painted on after the soap has been rinsed off and the skin dried. The eyelids when thus treated must be kept closed until the drying is complete. The patient should be informed before treatment that the staining from this solution will remain noticeable for several days.

Fresh areas of eruption should be treated as above described as soon as possible after their discovery.

BURNS OF THE FACE AND SCALP

The principles of treatment of burns of the face and scalp, as of those elsewhere, are asepsis, relief of pain, and avoidance of disfigurement if possible.

Burn of the First Degree.—The pain or discomfort is relieved spontaneously in from 2 to 3 days. The resulting redness lasts but a few days longer. Comfort follows the application of mild ointments with an organic grease as a base rather than those made of petroleum derivatives. Weak alcoholic solutions applied as wet dressings (see Wet Dressings) give relief in sunburn and first-degree burns.

Burn of the Second Degree.—The best application known to relieve pain and cause rapid drying up of blebs and growth of epithelium is picric acid. (See Picric Acid Dressings.) The skin is cleansed with normal saline solution and tincture of green soap applied with gauze or cotton sponges.

Blebs are opened with sterile scissors and their serum allowed to escape. If the cuticle of the bleb is very dirty it should be cut away and the raw surface of the true skin covered with overlapping narrow (½ inch) strips of sterilized gutta-percha tissue to prevent the adhering of the gauze dressings. Over all are applied a thin gauze dressing and bandage saturated with a one or two per cent. watery solution of picric acid. The patient must keep the dressing continually wet with sterile water until the surgeon replaces it on the following day.

The picric acid solution must not be allowed to come in contact with the patient's conjunctiva. If the burns involve the eyes that vicinity had better be dressed with boric acid solution.

Burn of the Third Degree. The aims of treatment of third degree burns are to relieve pain, to allow drainage, to keep the affected parts as nearly aseptic as possible and to prevent contracture of the scar.

Pain is relieved by opiates given either by mouth or hypodermically. The patient's general condition should command the surgeon's earnest thought and nourishment, elimination and rest should be provided for as well as possible under the circumstances.

The necrotic area of skin is watched for bulging, fluctuation, increase of tenderness, or other indications of the collection under it of pus and if this occurs a free incision through the slough will be needed. Cleanliness and drainage are promoted by the use of wet dressings of a weak (1:500) lysol solution, or calamine lotion may be applied. The dressings should be changed frequently enough to prevent them from becoming foul from accumulated excretions and moist enough to keep them pliable and comfortable. There is no advantage in removing the slough before it loosens naturally. This may require 2 weeks or more and after the slight remaining attachments of the dead skin have been cut through, the granulating surface which is revealed is dressed with a mild antiseptic ointment, such as one of ichthyol (5 per cent. or 10 per cent.), balsam of Peru (5 per cent.), or of Lassar's paste.

When healthy granulations have grown up to the level of the surrounding surface epithelium begins to grow over them from the edge or from any island of true skin which may have escaped destruction at the time of the burning. Epithelial growth over granulations is slow after burns of the third degree and is hastened or retarded by the corresponding general condition of the patient.

After third-degree burns of the face the surgeon should not wait for the slow natural process of healing. In these cases skin grafting is called for since it carries with it the advantages of hastening the repair process and of partly preventing serious contracture of the scar which is inevitable after spontaneous healing of a third-degree burn of the face.

FROST-BITE OF THE FACE

If seen before thawing has occurred the frost-bitten portion of the face is rubbed gently but long with snow, or gauze or cloths wet with cold water are applied. The temperature of such applications should be low at first—iced water, to begin with, and warmer water very slowly added so that the frozen skin is thawed gradually. In order that the temperature of the parts should not be too rapidly raised, the thawing should be conducted in a place where the temperature of the air is but little if any above the freezing point of water.

When once thawed and the circulation is seen to be reëstablished by the return of color to the surface, a mild antiseptic ointment is applied until the inflammatory reaction subsides.

If the frost-bite is first seen by the surgeon after thawing has taken place it is to be treated in the same manner as would be a burn of the same degree. If erythema only is present a mild ichthyol or other soothing antiseptic ointment is applied. If the frost-bite is of a more severe degree, as will be apparent by the occurrence of blebs or vesicles and pain, wet dressings should be used. Boric acid solution is suitable in any case, but if the location of the lesion permits, picric acid should be used. (See Picric Acid, page 526.)

Severe frost-bites which cause lesions corresponding to burns of the third degree are rarely seen about the face. They are treated by wet dressings and deodorants frequently changed until the slough separates when a plastic operation or skin grafting may be required.

LUPUS OF THE FACE

The surgeon should not forget the fact that, although the most important part of the treatment of lupus is local, the patient's general condition must be looked after.

Treatment with Carbon Dioxid Snow.—(See Carbon Dioxid Snow, page 522.) This method gives better results than do excision, curetting, cautery, escharotics, or the Finsen light. It is applicable to the nodular form of the disease, to ulcerations or to recurrences in cicatricial tissue. The operator will perhaps be apt to err on the side of insufficient application. If treating an ulcer of moderate size with a thin base the ordinary dry snow pressed firmly upon it for from 90 to 120 seconds

will suffice. In the case of thicker, larger lesions it will be necessary to lower the temperature of the snow by mixing ether with it as described in the article above referred to.

Large surfaces of lupus should be treated in a series of sittings. Each application should be to an area of from ½ to ¾ in. in diameter, with the piece of snow shaped to suit the contour of the lesion. Ten days more or less should elapse between applications to contiguous areas.

ACTINOMYCOSIS OF THE FACE

Attempts at prophylaxis and cure of this disease by serotherapy have failed.

The iodids internally have long been believed to exert a favorable influence on the disease. Fördel, in 1908, showed 6 cases of actinomycosis cured by cacodylate of sodium internally. Salvarsan would seem to be logically indicated.

Surgical treatment combined with the internal administration of iodids has up to the present time offered the best results and those cases of actinomycosis occurring about the face and neck which have given the disease its vulgar name of "lumpy jaw" are the ones with the best prognosis.

In the nodular stage a free incision and curetting will furnish the material for verifying the diagnosis under the microscope. It will also cure the disease if all the mycotic infiltration be removed. If not and if healing does not follow, a total extirpation should be considered in spite of the serious inevitable scarring.

The usual form of the disease when recognized as such consists of a dark irregular patch of infiltrated skin and subcutaneous fascia, with perhaps sinuses and pus pockets here and there. The treatment of such foci of mixed infections should consist of free incision to the deepest parts of the infiltrated areas, with curetting of sloughs and softened tissues followed by the application of tincture of iodin in the cavities. Several operations of this kind may be required and should be always supplemented by the internal administration of iodid.

It should be borne in mind that total extirpation is the surest method of cure when it is possible and when not, recourse must be had to thorough drainage, curetting and the application of tincture of iodin.

ANTHRAX OF THE FACE

As soon as the nature of the pustule is recognized, cultures should be taken from it and it should be excised. The cultures are used for the manufacture of autogenous vaccines to be administered when ready. Next to be preferred after excision, multiple incisions and thorough swabbing of the wounds with tincture of iodin are the procedures of choice. Vaccine treatment of anthrax

has been proven to be efficacious in reducing mortality both in man and animal. While awaiting the completion of the autogenous vaccine, surgical treatment as outlined above should be given. The use of a stock anthrax vaccine obtained from a reliable source is recommended.

Preventive inoculations have also been found to be of use in producing immunity to anthrax and may be used in persons likely to be exposed to infection. (See article on Vaccines.)

TUMORS OF THE FACE AND SCALP

MOLES OF THE FACE AND SCALP

Removal of moles of the face and scalp is called for not only by their unsightliness but also by reason of the fact that they not infrequently degenerate into malignant growths.

Excision.—Excision is the method most generally satisfactory and is usually done under local anesthesia. Enough epinephrin solution (1:10,000) is added to the local anesthetic to cause blanching of the vicinity and give a bloodless field.

A small pigmented mole without hairs may be grasped at one edge with a fine-toothed forceps and while traction upward is made with this the cuticle and pigmented layer of the skin are excised with sharp-pointed scissors curved on the flat, or with the scalpel. The deeper layer of the true skin is thus left remaining and the area will be regenerated so that there will be no cicatrix. A wet or ointment dressing is applied until epithelium covers the little wound. A 5 per cent. ointment of scarlet red seems to hasten the growth of epithelium over healthy granulating or uninfected abraded areas.

Excision of Larger Moles.—In the case of moles more than half an inch in diameter, and of smaller hairy growths, whether pigmented or not, the whole thickness of the skin must be removed. Two curved incisions, whose ends meet, are made to inclose an area of skin including the mole. (See Figs. 13, A and B.) The direction of these incisions is planned so that when drawn together after excision of the whole area inclosed by them, the line of the wound is in the direction of a normal incision. (See Normal Incisions.) Unless this caution is observed it will be difficult to obtain neat approximation of the wound edges and an inconspicuous scar. The incision should be made without any ragged nicks. The skin is grasped with toothed forceps or hooked with a tenaculum at one point of the ellipse and while upward traction is made, the whole area of skin is cut away from the subcutaneous fascia. If tension of the skin occurs on bringing the wound edges together they should be undermined for a short distance so that there will be no stretching and thinning of the scar. To undermine the skin, its edge is grasped with the thumb forceps while the scalpel or scissors cuts its attachment to the underlying subcutaneous fascia. Bleeding is checked by pressure with gauze pads and by ligation of all bleeding points where needed. The wound edges are approximated with Michel clamps (q. v.) or with sutures of horsehair or silk applied by the subcuticular method (q. v.) or with narrow strips of sterile adhesive plaster (q. v.). A dry sterile dressing is applied and the sutures, clamps, or adhesive strips removed in from 3 to 5 days. Sutures should be removed as early as the third day unless it is apparent that the wound will gape without their support. If left longer than this, their puncture marks in the skin will be more or less permanent. If the suture line coincides with the normal incision lines the wound edges will not be apt to gape. When the sutures are to be removed early it may be well to apply adhesive strips across the wound just before they are cut.

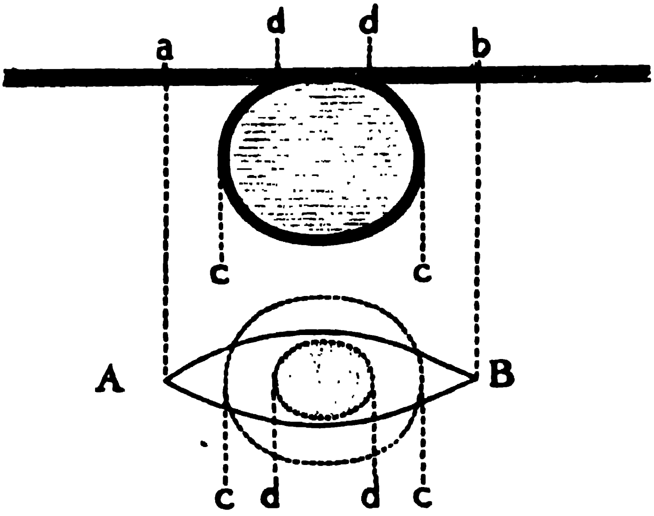

FIG. 13.—DIAGRAM SHOWING PROPER INCISION FOR EXCISION OF A CYST WHICH IS ADHERENT TO SKIN. The upper figure shows a side view of the cyst whose upper wall blends with the skin between d and d. The lower figure shows the outline of the cyst in dotted lines with the stippled area that portion of the cyst wall adherent to the skin (d d). The elliptic incision A B (a b) encloses this adherent area.

It is often possible to obtain a particularly neat result by making the incisions through the skin in a direction oblique to the surface instead of at right angles, so that after removal of the mole, the wound edges may be approximated in an overlapping manner. A wound made in this manner and nicely approximated by adhesive strips will often result in an invisible scar.

Treatment by Carbon Dioxid Snow.—Moles less than half an inch in diameter may be removed by freezing with this substance. Their removal requires more pressure and much longer exposure to the refrigerating effect of the snow than are necessary in the treatment of other lesions. The snow should be mixed with ether, packed into a hard mass, and applied long enough not only to freeze the mole but also a ring of healthy tissue around it. At least 2 minutes will be needed to destroy the average mole in an adult. Moles of the hairy scalp are better subjects for removal by the snow than are those of the face for the reason that if scarring should follow an overdose of the snow it will be hidden in the hair. In applying the snow to a mole it is better to err at first on the side of too little time. At a subsequent sitting the time of exposure may be increased. It is safe in the case of adults in ordinary conditions of health and vitality to give an exposure of 2 minutes to a half-inch mole at the first sitting; if unsuccessful a longer treatment follows in 10 days or 2 weeks.

ANGIOMA OF THE FACE AND SCALP

The object of treatment of angiomata of the face or scalp is primarily to rid the patient of a disfigurement. No means has yet been employed which does not cause a scar but in this respect the application of carbon dioxid snow when available is an improvement over former methods. While it is true that some capillary angiomata (port wine marks) become less conspicuous with time if untreated, it should also be remembered that they and perhaps more cases of cavernous angioma sometimes tend to increase in size. It has been suggested that the present rarity of cirsoid aneurysms is due to the fact that ordinary angiomata are operated upon more frequently than was formerly the case.

The vascular overgrowth in capillary nevi is confined to the skin while large or rapidly growing cavernous angiomata often involve the subcutaneous fascia and when occurring over the fontanelles of infants may communicate directly with the longitudinal sinus. The latter cases are difficult and tedious but are usually amenable to patient treatment by galvanopuncture.

The methods of choice in the treatment of angiomata of the face and scalp are excision, the application of carbon dioxid snow, galvanopuncture (electrolysis), and ignipuncture (actual cautery).

The selection of the operation will depend upon the character and site of the angioma and the patient's age.

Excision.—Excision is the method of choice in the case of small or pedunculated angiomata, for here the edges of the wound can be approximated without tension and a slight linear scar is the result. The incision, usually elliptical about the base of the tumor, is made so that when its edges are approximated, the line of the scar will be in the direction of the natural wrinkles of the face. (See Normal Incisions.) If the cut is made through the surrounding healthy skin, no unusual hemorrhage will be encountered. (See Cysts of Face and Scalp.)

Carbon Dioxid Snow.—Carbon dioxid snow in the treatment of cavernous nevi of all sizes about the face has come into widespread use and gives its best results in those tumors which are raised above the surrounding surface. Its results are least favorable in flat growths and those covered with a thick integument. Angiomata of the ordinary "strawberry mark" type in young children respond well to this treatment. The general technic of the application of carbon dioxid snow is described on page 522. In treating angiomata the amount of pressure should be great enough to make the growth bloodless. The duration of the application of hard dry snow will range between 20 seconds in the case of a superficial nevus on an infant's face to 90 seconds pressure upon a deep growth in an adult.

The snow should be pressed on firmly enough to freeze the whole mass under it. In nevi less in diameter than ½ inch in infants or ¾ of an inch in adults the whole growth should be frozen at one sitting. Larger angiomata are treated by two or more applications to adjoining areas at intervals of about 2 weeks. Care is necessary to avoid too long an application, especially in the tender tissues of infants or young children and in the case of lesions situated immediately over bony surfaces. An ulcer followed by an unsightly scar may result if an overdose of the snow is given.

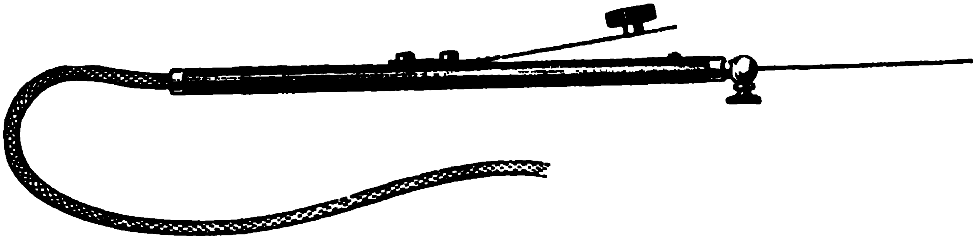

FIG. 14.—NEEDLE ELECTRODE FOR REMOVAL OF SUPERFLUOUS HAIR. With a coarser needle substituted, this may be used for galvanopuncture of nevi. The cord contains a conducting wire and the circuit is closed by pressing down the switch button.

(For further details concerning the use of carbon dioxid snow see page 522.)

Galvanopuncture; Electrolysis.—This painful procedure requires local anesthesia in patients over 2 or 3 years old. Infants are operated upon without anesthesia while firmly held by an assistant. The pain ceases when the needle is removed.

The electric current is furnished by a battery of chemical cells or by the electric light current reduced to the proper voltage and amperage.

A sponge electrode is electrically connected with the positive pole of the battery and the needle electrode (see Figs. 14 and 15) for puncture is connected with the negative pole. An iridoplatinum or platinum needle is the best, as it will not be corroded so quickly by electrolysis as will steel and is less apt to leave visible puncture marks. If steel needles are used a fresh one should be provided for each operation. The needle is inserted into a holder provided with a connection for the conducting cord and a switch as shown in Figure 14. If a milliammeter is used the current is regulated to a strength of from 3 to 10 milliamperes. A rough but practicable test of the current strength may be made by immersing both the sponge and needle electrodes near to each other in a 5 per cent. aqueous sodium chlorid solution. Starting at zero, the rheostat or galvanic cell switch is moved slowly until enough current flows to cause fine bubbles to gather about the needle and rise to the surface. Leaving the switch at this point the sponge electrode is pressed firmly against the patient's skin at a convenient place nearby.

With the current on, the needle is pushed into the tumor near its edge and deeply enough to penetrate to its bottom. If the current is of proper strength blanching of the surface will occur about the needle which is allowed to remain in place for about 10 to 20 seconds before being withdrawn. The escharotic effect of the current prevents hemorrhage upon withdrawal of the needle. Several such punctures 1/8 in. or more apart are made at a sitting. If the skin over the nevus is especially thin and bleeding occurs in spite of the electrolysis, the needle should be introduced through healthy skin about the periphery before passing into the growth.

Sufficient time, perhaps a week, should elapse between treatments so that any inflammatory reaction may have time to subside. It is well to attack at each sitting an area somewhat removed from the site of the last preceding punctures. Many such treatments may be required in the case of large angiomata but the final results are good and are surpassed only by those obtained in cases which have been successfully treated by the application of carbon dioxid snow. A cicatrix is left after electrolysis, which will be more or less noticeable as the vessels of the angioma were more or less large.

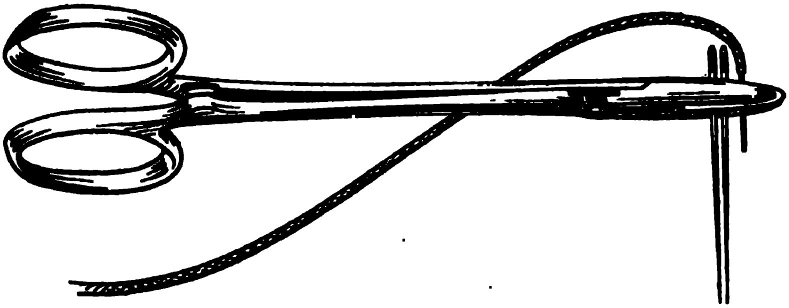

Fig. 15.—Electrode for Galvanopuncture Improvised from an Artery Forceps and Two Sewing Needles. With the conducting card discarded, needles held thus, and heated to incandescence may be used for galvanopuncture.

Ignipuncture.—Ignipuncture as a method of treating angiomata of the face and scalp requires mention although it is to be chosen only when carbon dioxid snow and galvanopuncture are not available. Its disadvantages are the inflammatory reaction, crusting, and the resulting cicatrix which is usually more rough and unsightly than that following the use of refrigeration or electrolysis.

Anesthesia is required in most patients. Nitrous oxid gas is especially applicable. If ether is used, there will be danger of its fumes becoming ignited. Infants not anesthetized are held by an assistant.

The object of the operation is to destroy the growth by heat. An incandescent metallic point is plunged into the angioma at one or more points at each sitting. The cicatrix after the burn supplants the vascular growth. The simplest method is to use one or two needles of platinum or steel grasped in a pair of artery forceps (see Fig. 15) and heating their points in an alcohol flame held close by. When red hot their points are pushed into and through the angioma and withdrawn. If the needles are too hot or not hot enough, bleeding is apt to follow their withdrawal. A dull red color indicates the proper degree of heat. If the Paquelin cautery is used with a fine sharp-pointed tip, the heat may be managed better than with the flame-heated needle. The galvanocautery furnishes another means of supplying an incandescent metallic point and may be used as above described.

CIRSOID ANEURYSM

In marked cases those methods of treatment available at the present day are of little avail. In cirsoid aneurysms of small extent total excision with ligation of all afferent vessels, followed by a plastic operation or skin grafting to cover the denuded area, is the treatment of choice.

HORNS OF FACE AND SCALP

These odd growths of the skin do not recur when their bases are excised. An elliptic incision is made through the skin so as to include the base of the excrescence and the wound edges are approximated with sterile adhesive strips, sutures or Michel clamps in the usual manner. The surgeon should bear in mind the possibility that the base of any horn seen may have begun to undergo epitheliomatous degeneration.

NEUROFIBROMATOSIS OF THE SCALP

(*Recklinghausen's Disease*)

When the nerve tumors occur, as they are prone to, about the temporofrontal region of the scalp, distressing the patient by their unsightliness, they should be removed by excision with the knife. They do not extend below the subcutaneous fascia but are often well supplied with vessels and the surgeon should be prepared to meet with free hemorrhage. The scalp hemostatic forceps shown in Figure 10 will be serviceable to control this. The wound is closed and treated in the manner described under Scalp Wounds and Cysts of the Scalp.

LIPOMA OF FACE

Lipoma of the face usually occurs upon the forehead and remains of moderate size. The indications for its removal are the fact that it is a disfigurement and the possibility of its degenerating into a malignant growth or suppurating as a result of trauma and infection.

The scar after excision, if it be in the line of a natural wrinkle or normal incision line (see Normal Incisions), will be but slightly noticeable. It is the easiest form of tumor to enucleate as it may be readily shelled from its bed if the operator is careful to cut down to the true capsule before beginning to enucleate. Removal is accomplished in much the same manner as that used in excision of a sebaceous cyst (q. v.).

The blunt-pointed scissors, curved on the flat are pushed while closed, into the plane of fascia next to the growth and there cautiously opened while traction is made upon the fatty mass. This procedure is repeated until it is completely separated from its attachments. Here and there a band of fascia or vessel passing to the lipoma must be cut. If a vessel, it is tied and cut between tumor and ligature. Accidental incision of the true sac does not complicate the operation by allowing escape of its contents as would be true in the case of a cyst.

The suturing and after-treatment are carried out as in the case of excision of a cyst.

SUPERFLUOUS HAIR OF FACE

(*Hypertrichosis*)

Electrolysis furnishes the only practicable means by which a patient can be rid of superfluous hair upon her face. The method used is to introduce a fine needle into each individual hair follicle alongside of the hair to be destroyed and pass a galvanic current through it. The technic is not especially difficult but the process is tedious and not always satisfactory. There may be thousands of hairs to be removed, and it is seldom practicable to treat more than thirty at one time. Moreover, even the best results show about 20 per cent. of recurrences which means repetition of the treatment in just so many hair follicles. Also hairs which were so fine as to be unnoticeable may grow coarse enough to require treatment later, so that altogether patient and operator should be prepared for a series of sittings extending over much time.

Operation.—A fine steel needle or preferably one made of iridoplatinum is held in an insulated handle and connected by a flexible conductor with a battery of cells or reduced electric light current. (See Fig. 14.) The handle is provided with a spring switch by which the current can be turned on or off by the operator's fingers. This electrode is connected with the negative pole of the battery. The positive electrode is a sponge with an insulated handle and moistened with an aqueous solution of sodium chlorid, pressed firmly by the patient against her skin at some convenient place near the superfluous hair under treatment.

Before turning on the current the needle is inserted in the hair follicle to its deepest part. The battery switch is then moved so as to allow a current to flow which will give a reading on the milliampèremeter of from 2 to 5 milliampères. When the current has flowed for a few seconds (15 to 20), and when a few minute bubbles appear at the site of puncture or a little redness is seen the current is broken. The hair is then removed without traction by a pair of thumb forceps and another hair at a little distance (1/3 inch or more) from the previously treated one is attacked. Some pain is caused by the treatment and certain areas of the face are more sensitive than others. If the current is too strong or too long applied, pitting of the skin will result. Slight scarring is almost unavoidable but is preferred by most patients to the presence of superfluous hair. This treatment is especially applicable to hairy nevi which contain a few coarse hairs.

SEBACEOUS AND DERMOID CYSTS OF FACE AND SCALP

A sebaceous or dermoid cyst of the face or scalp will require surgical treatment varying with its particular nature or stage of development or with existing complications.

Such a cyst in its simplest form is inclosed in a sac of firm smooth connective tissues and is freely movable in the surrounding fascia. In this state it may be dissected out with its sac intact, through a skin incision.

A cyst of long standing will often be found to be adherent to its surroundings and immovable in its bed in consequence of past traumatisms or infections which have caused exudations to form about it. Under such circumstances as these the operation for its removal must be of a different nature.

In the case of a cyst on the face which is inflamed or infected, it will be proper to endeavor to allay the inflammation by a continuous wet dressing. If this attempt be successful, a clean dissection and enucleation of the intact sac may be made later, as described below. If unsuccessful, and the suppuration of the cyst becomes apparent, then a free surgical incision is made, the sac's contents are evacuated, the cavity packed loosely with sterile gauze and the wet dressing continued for a day or two until a healthy granulating process begins. If the sac be a small one it may be scraped away at the time of the operation with a Volkmann spoon if its smooth white surface or parts of it be seen on retraction of the wound edges. But if suppuration have existed some time, it is possible that the secreting function of the sac will have been destroyed and that, when the granulations have filled the cavity, there will be no recurrence of the cyst formation.

OPERATION FOR EXCISION OF UNCOMPLICATED CYSTS

The skin incision is made along the greatest diameter of the cyst or, if its outline be circular, the knife should follow the direction of skin cleavage, the so-called normal line of incision, as described by Kocher (see Fig. 6) in order that the subsequent scar may be as inconspicuous as possible. To this same end it is well among selected cases of operations upon the face in general to make the skin incision with the flat sides of the knife held at an acute angle with the skin surface. When the edges of a wound made in this manner are brought together again and sutured it will be found that the pressure of the dressing aids in making an especially neat approximation and a subsequent scar which is almost invisible. If, however, Michel clamps (Fig. 8) are to be used in place of sutures, it will be better to make the skin incision in the usual fashion at right angles to its surface.

The scalpel is used cautiously while cutting down upon the sac in order to avoid opening it unawares. A bloodless field is maintained by wiping with gauze and by the hemostatic forceps. Good retraction of the skin edges is essential. If assistance be scant the operator will find useful a self-holding retractor such as that devised by me and described on page 529. During the dissection the finger tip is frequently used to give a clew by the sense of touch to the location and proximity of the tumor. Enucleation should not be begun until the sac is actually exposed to view. It is a common fault of unskillful operators to begin to remove the sac before the last layers of surrounding connective tissue have been penetrated.

When the incision seems to be close to the sac it is well to lay aside the knife and to use in its place a pair of medium-sized blunt-pointed curved scissors. As the meshes of the fascia enveloping the cyst are picked up by the thumb forceps with one hand, these scissors, held in the other with their blades nearly parallel to the surface of the sac, open a way toward its smooth surface, either by cautious cutting or by blunt dissection (tearing) while closed, or by being pushed into the tissues near the sac and then forced open, thus tearing apart the trabeculæ of fasciæ and opening the way toward complete exposure of the cyst.

When the presenting aspect of the cyst has thus been bared, it is grasped with a forceps and carefully shelled out of its bed by a continuation of the above-described blunt dissection. Actual cutting is needed only for those attachments of the tumor which refuse to be separated by the blunt instrument, or else they are pushed aside and left behind intact. Each band which is cut must be first examined and, if found to contain a blood-vessel, must be caught in a hemostatic forceps and must be cut between them and the tumor, and later ligated if need be.

If the cyst should be inadvertantly opened, a part of its contents may be received on a gauze pad and removed without contaminating the wound. When enough of the cyst contents are removed to make flaccid the sac, the opening may then be closed in the bite of a pair of hemostatic forceps which are used as a handle to the cyst during the remainder of the operation for its enucleation.

Occasionally a thick-walled non-adherent cyst, if accidentally opened, may be shelled out from its bed by catching it firmly with forceps as just above described and twisting and pulling it out from its bed without any cutting.

Any vessels which bleed after the removal of the artery forceps are again grasped and ligated with catgut. The cavity remaining in the tissues is obliterated by means of the pressure of the dressing and bandage. If it be determined that such pressure will not suffice to close the cavity, its sides should be brought together by one or more catgut sutures applied with a curved needle. The skin incision is closed with fine sutures of silk or horsehair, or by skin clamps (see Fig. 8), or by narrow strips of adhesive plaster. If sutures are used upon wounds of the face they should be removed early—by the third or even the second day—so that hair puncture wounds will heal and quickly disappear. A subcuticular continuous suture of silk (see Fig. 3) is especially adapted to wounds of the face because when well applied they leave but inconspicuous scars.

On account of probable oozing from the wound during the first day after operation the dressing should be a generous one of sterile gauze and bandage. After this, unless needed for obliteration of the wound cavity, the bandage may be dispensed with and the wound may be protected until healed with a small dry dressing held in place by adhesive strips or collodion.

OPERATIONS FOR CYSTS WHICH ARE ADHERENT TO THEIR SURROUNDINGS

Many dermoid and sebaceous cysts become adherent to the fascia and to the overlying skin which becomes thinned, shiny and often reddened, and presents the symptom of superficial fluctuation. If in the hairy scalp the hair over the cyst may disappear.

In these cases the incision should take the form of an ellipse which contains the thinned area of the skin. This area is left adhering to the cyst and is excised with it so as to avoid puncture of the sac. (See Fig. 14.)

If adhesions are present all about the sac it will of course be impossible to shell out the tumor alone without bringing away some surrounding fascia. In these cases the aim of the operator is to cut as closely to the sac as possible. The best dissecting instruments under these circumstances will be blunt-pointed scissors curved on the flat and mouse-toothed forceps. The aim here will be, as in all dissection, to maintain a bloodless field and good retraction and not to cut anything unseen. If the sac be inadvertently punctured and its contents escape into the wound they should be carefully picked or wiped out. If they are purulent and escape into the wound it should be washed out with saline solution and drainage maintained for a day or two.

Cysts at the outer angle of the orbit require excision under circumstances similar to those in other situations except for the especial necessity of checking bleeding during and after operation on account of the liability to ecchymosis in the loose fascia about the eye. The incision is made if possible in the line of the eyebrow after shaving. It is extended but little if any beyond the outer end of the brow, so that it may be afterward concealed by the hair. Strong retraction may be necessary to expose the cyst through the skin wound.

MALIGNANT GROWTHS OF THE FACE AND SCALP

It is the duty of the surgeon to remove all traces of any malignant growth no matter where it is situated. Skin specialists whose attention is confined more or less to smaller and more superficial epitheliomata, are accustomed to use caustics while the practice among surgeons is to depend upon the knife in eradicating malignant growths of all kinds.

Epithelioma as encountered about the face and scalp usually originates in the skin or mucous membrane while sarcoma is more commonly found to have started in the upper or lower jaw or orbital structures and to be obviously beyond the reach of escharotics. (See Excision of Upper and Lower Jaws.)

EPITHELIOMA OF THE FACE

The cutting operations for epithelioma of the face involve excision of the neoplasm together with a generous amount of surrounding normal tissue and all affected lymph nodes. The knife offers the surest means of cure available at present. Fortunately epithelial cancer upon the face is usually slow of growth and lymphatic involvement does not occur until the disease is well advanced. For this reason permanent cure after prompt and thorough excision of such growths is to be hoped for.

Operation.—A small epithelioma of the face which as yet appears as a slightly pigmented patch or papule or which has but recently and superficially ulcerated and has left the skin freely movable upon the tissues beneath, may be excised through an elliptic incision large enough to include a generous margin of surrounding healthy skin and subcutaneous fascia. In other respects the operation is similar to that for excision of a mole. (See Moles of the Face.) The specimen removed should be examined microscopically in order to verify the diagnosis and to ascertain if any epitheliomatous tissue extends as far as the line of incision in any direction. If it should do so, a more extensive operation should follow without delay.

An epithelioma of larger extent or which is complicated by the existence of diseased lymphatics will require excision of so much tissue in order to give hope of thorough eradication of the disease that a plastic operation to remedy the remaining defect will be necessitated. Plastic surgery of the face is described elsewhere in this work. As an immediate sequel to the excision of extensive carcinoma of the face,.as of other parts of the body, fulguration by sparks from an Oudin resonator or Tesla coil has been proven to be a valuable adjunct in making the cure complete and thus preventing recurrence. (See Fulguration.)

If permission for a radical operation be refused, the surgeon has beside excision a number of methods from which to choose for the destruction of superficial epithelioma of the face. Each method has been successful; each has sometimes been followed by recurrence. In the absence of reliable statistics of the end results of these procedures one must be guided in his course by the type, location, severity of the lesion, presence or absence of glandular involvement and the means of treatment available in any given case. These methods include the use of the following agents:

(1) Carbon dioxid snow (q. v.)
(2) Radium (see article in another part of this work)
(3) X-ray (see article in another part of this work)
(4) Fulguration (q. v.)
(5) Caustics

MALIGNANT GROWTHS OF THE SCALP

The diagnosis of malignant growths of the scalp should be confirmed by microscopic examination of a section or sections of the growth removed for that purpose with knife or curet by a competent pathologist. The specific test of the patient's blood for syphilis will not infrequently show that which had been taken for an epithelioma to be a gumma or syphilitic ulcer.

Once the malignant character of the growth has been ascertained the operation for its excision should be performed in a radical manner and preferably under a general anesthetic.

A malignant growth of the scalp with extensive involvement of the skull is not a proper case for excision. In such cases the surgeon should bear in mind the possibility of a cure by Coley's fluid, radium, or the X-ray.

Operation.—The head is shaved and sterilized over an area large enough to insure accessibility to considerably more than the field of operation as well as cleanliness during the operation and repair process. The incision is carried around outside the circumference of the growth and at least half an inch beyond any suspicious appearance of the skin. It extends to but not through the periosteum unless this be involved in the neoplasm. The scalp is then dissected up and away from the skull while a bloodless field is maintained by the use of the ordinary hemostatic forceps, or, when these fail, such special scalp forceps as those shown in Figure 14. It will rarely be necessary to leave them in place for 12 to 24 hours. Ligation of the vertex (see Fig. 4) is a practical means of controlling hemorrhage during operations in that locality. Oozing from exposed bone or periosteum usually ceases under the pressure of the gauze dressing held in place by the bandage.

During the dissection the growth is handled as little as possible to avoid its dissemination but traction upon it is made with a hook or volsellum. If the periosteum or skull is involved by the malignant growth over a small area or if merely adherent to it the outer table should be chiseled off or a trephining operation be performed. (See article on Surgery of the Skull.)

After the excision is complete and bleeding is checked, fulguration applied to the raw surface will lessen the probability of recurrence of the disease.

The wound is closed as much as possible by undermining the edges.

It may be necessary in extensive wounds to do this for the distance of an inch and a half or more out into the tissues around the whole circumference of the wound area. The scalpel is used to cut in the plane of the loose fascia between the periosteum and the aponeurosis of the occipitofrontalis muscle so as to permit sliding of the wound edges toward each other. Deep silkworm-gut sutures are used with care not to cause too much traction upon them. They may sometimes be reinforced by long adhesive straps. Skin grafting is available in those cases where the gap cannot be closed by suture. The grafts may be laid on the fresh raw surface if fulguration has not been employed. If it has, the skin grafting is not applicable until healthy granulations have covered the wound area.

INOPERABLE MALIGNANT GROWTHS OF FACE AND SCALP

The therapeusis of malignant growths of the face and scalp does not end with operative procedures. Advanced inoperable cases will tax the surgeon to alleviate the misery of their victims and those persons coming into contact with them.

The symptoms to be dealt with in these cases are pain, offensive discharge, cachexia, and disfigurement.

Pain.—Sooner or later in most cases the habitual use of morphin with all its disadvantages must be resorted to. The question of the proper moment to begin with the drug is a serious one for after it is past the patient is inevitably swept into a drug addiction from which he will be freed by death only. The undesirable psychic and physical effects following the habitual use of morphin may be postponed in many cases by the use of codein. This should be used to relieve pain as long as it continues to be effective. Starting with doses of half a grain (.03 gm.) of codein by mouth or with the same amount of codein sulphate given hypodermically from once to 4 or 5 times a day, the dose is increased up to 2 or 3 grains (.12 gm. to .24 gm.) every 3 or 4 hours. Beyond this amount of codein it is useless to go and when this drug becomes ineffective in relieving pain morphin (1/4 gr.) guarded with atropin (gr. 1/150) preferably by hypodermic syringe, must be given. The constipating effect of these drugs must be combatted by the use of laxatives.

Local Anodynes.—If the malignant growth which causes pain be ulcerated and the procedure be practicable, relief for many hours may be possibly attained by the injection into it with a hypodermic syringe of a solution of quinin and urea hydrochlorid. (See article on Local Anesthesia, elsewhere in this work.) A local anesthetic effect upon painful ulcerating surfaces may often be obtained by the application in powder form of orthoform (meta-amido-para-oxybenzoate) which in addition to its property of causing local anesthesia upon ulcerated surfaces, is also antiseptic. Anesthesin (ethyl aminobenzoate) is also a drug with local anesthetic properties and may be sprinkled upon painful ulcerated surfaces. It may be combined with boric acid powder in equal parts since its antiseptic qualities are feeble or lacking.

Offensive Discharges.—Of first importance in combatting the offensive discharge of an advanced malignant ulcer are frequent cleansing and change of dressings. Peroxid of hydrogen is an effective deodorizer. After irrigation with it, a dressing wet with lysol in dilute solution (1:400 to 1:200) may be used. Phenol (1:100) or creolin (1:400) in water may be used in preparing deodorant wet dressings. Oakum is used sometimes as a deodorant dressing.

Cachexia.—It is the duty of the surgical attendant to give unrelaxed attention to every symptom presented by his case of advanced inoperable cancer. The fight against loss of strength and flesh will require the use of nourishing, concentrated, easily digested food, rest and every possible attention to the physical and mental requirements of the sufferer.

Disfigurement.—What cannot be cured may perhaps be hidden. The exposed situation of malignant growths of the face and scalp makes it proper that especial means be devised to hide them. To this end dressings should be as small as due care permits. Black silk or muslin bandages and even black adhesive strips have a neat appearance and should be used if they please the patient. The arrangement of a woman's hair or clothing may for a time help to hide an unsightly dressing.

DISEASES AND INJURIES OF THE BONES OF THE FACE

INJURIES TO THE BONES OF THE FACE

Fracture of the Upper Jaw

Fracture of the upper jaw is produced by direct violence and is usually confined to its processes occurring in company with injuries to other bones. The alveolar process may be broken wholly or partly off; the malar bone may be driven into the antrum; the jaw may be broken apart from its fellow of the opposite side along the median line or a fissure may be found to extend from a point in the upper jaw up into the skull. Division and final obliteration of the tear duct may result from fracture of this bone. When the fracture is compound with the wound opening into the mouth, salivation and an offensive discharge are to be expected from the necrotic area about the break and frequent careful cleansings are necessary. But the ultimate results after fracture of the upper jaw are usually good. Repair is usually complete in about 5 weeks. There is but little callus formation.

It is sometimes difficult to overcome the tendency to displacements of the fragments during the healing process and, where it is evident that deformity will result, the surgeon must be prepared to perform an open operation for the replacement of depressed portions of the bone and to exercise his ingenuity to provide some means to overcome the displacements. Small fragments of bone are not to be removed unless they become necrotic. Immobilization of the upper jaw by an interdental splint is applicable in certain cases, especially when the alveolar process is involved. A competent dentist should be called upon to supply this.

In fractures of the upper jaw accompanied by depression of the thin outer plate which may be driven into the antrum, the following method of operation may be followed:

Operation.—LOTHROP'S METHOD.—The patient is anesthetized and placed in the semirecumbent or sitting posture. Gwathmey's method of rectal oil-ether anesthesia is well adapted to use in this operation. The cheek is retracted from the teeth and an incision is made in the mucous membrane for an inch along the upper border of the alveolar process. The soft parts (of the cheek) are separated from the bone with a periosteal elevator. This incision is made from the canine ridge backward. A finger passed into this incision may feel the line of fracture and, if so, a director or stout probe is passed along it as a guide through the fissure into the antrum and used to elevate the fragment to its normal level. If no fissure is felt, the director is forcibly pushed through the thin wall into the antrum just above the second bicuspid tooth and is then used to elevate the depressed portion of the antral wall. It may be necessary to use stouter and coarser instruments than the director, in which case a No. 24 or No. 22 French male urethral sound may be pushed through the wall of the antrum upon the director which has been left in place as a guide.

As after-treatment one or more wicks of gauze are inserted as drains to the deepest part of the wound in the soft parts and removed in 24 or 48 hours. The mouth is kept clean by the use of a mild antiseptic mouthwash. For this purpose nothing is better than a light beer-colored dilution of tincture of iodin in water. If there is much swelling of the face a wet dressing is applied. (See Wet Dressings.)

The patient must not be allowed to lie upon or touch the affected side of the face or he may cause recurrence of the displacement of the fragment.

Fracture of Malar Bone

Treatment of fracture of the malar bone with lines extending into the upper jaw and noticeable depression calls for a modification of the above-described method of Lothrop. The first steps of the two operations are identical. In order to elevate and replace the depressed fragment of the malar bone a No. 21 to No. 24 French male urethral sound is passed into the antrum to its apex which is adjacent to the malar bone, with the convexity of the curve of the instrument directed inward and backward. . The patient's head is held firmly by an assistant while the operator grasps the sound with both hands in the following manner: His left hand, with the palm uppermost, rests upon the patient's face, acting as a fulcrum as it holds the instrument near its curve, while his right hand takes the handle end. Strong but well-controlled pressure upward and outward can thus be exerted upon the fragment. It is thus pushed back into its normal position which may be recognized by the palpating finger externally. Any detached fragments of bone about the opening into the antrum are sought for with a forceps introduced on the finger as a guide and are removed.

Sterile gauze wicks are introduced into the wound in the cheek as drains and are left protruding a little into the mouth. A light wet dressing is applied to the left side of the face. The diet is restricted to liquids for a week and the after-treatment conducted as described above.

Fracture of the Zygoma

A fracture of the zygoma is usually accompanied by deformity of the face on account of the depression of one or more bony fragments as the result of direct violence. The surgical treatment aims to correct such deformity.

An incision with its center directly over the depressed fragment is made under general anesthesia, in the direction of a natural wrinkle of that portion of the face. This incision is continued down to the bone while ample retraction is made and a small curved periosteal elevator or blunt hook is slipped under it. Traction and manipulation are used to replace the fragment which will usually remain in good position. If, however, the displacement shows a tendency to recur it may be necessary to suture the fragment to the sound portion of the bone. The wound is closed with Michel clamps (q. v.) or with sutures of silk or horsehair and the dressing applied so as to prevent direct pressure upon the wound by fashioning the gauze pads into the shape of a large corn-plaster. The patient is instructed to avoid lying upon or touching the dressing during the time in which the fracture is uniting which will be for about 2 weeks in uncomplicated cases.

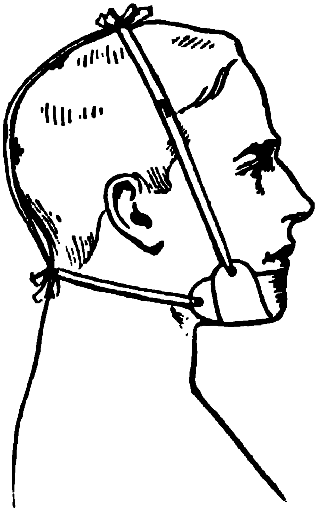

Fig. 16.—Xylonite Splint for Injuries of Lower Jaw.

Fracture of Lower Jaw

Fracture of the lower jaw occurs most frequently somewhere in the body of the bone and is usually accompanied by displacement of the fragments. In a small number of cases the fragments are found to be in good position and may remain in place under a simple, firm and frequently adjusted four-tailed bandage of stout muslin with its center over the point of the chin, or a xylonite splint (see Fig. 16). Usually, however, there is a displacement of the fragments accompanied by a break in the regular alignment of the teeth which persistently recurs if a proper splint is not applied. In fact, the practical guide to satisfactory reduction of the deformity is a proper realignment of the biting surface of the teeth.

Fracture of the lower jaw seldom requires suturing of the fragments or plating. The fracture is usually infected by the bacteria of the mouth either by being compound with the wound through the mucous membrane or else through the tooth sockets which in so many persons are chronically infected, i. e. are the site of a more or less severe Rigg's disease. The time-honored method of holding the fragments together by means of a silver wire passed around teeth on either side of the fracture after reduction of the deformity may be resorted to in favorable cases if it is impossible to obtain the services of a competent dentist who will prepare a suitable interdental splint as mentioned below. If wiring of the teeth is attempted it should be of those not adjoining the site of fracture as they are pretty sure to be loosened thereby and the procedure rendered a failure.

The reduction of the deformity is accomplished by manipulation of the fragments, under an anesthetic if need be. The surgeon grasps the fragments both inside and outside the mouth with the fingers of both hands. Once reduction is accomplished the fragments must be splinted so as to maintain their correct position. In the vast majority of cases it is the best practice to immobilize the fragments, even where there seems to be no immediate tendency to their displacement, by means of the interdental splint. The farther the site of fracture is from the symphysis, the more tendency there will be toward displacement of the fragments.

When first seen, and until the dentist has prepared the interdental splint, a temporary four-tailed bandage or xylonite splint (see Fig. 16) is applied and especial directions are given to the patient to partake of a liquid diet and to keep the mouth as clean as possible by means of mouth washes such as dilute Dobell's solution or peroxid of hydrogen. A soft tooth-brush may be used to cleanse the outer aspect of the teeth and gums.

In preparing the interdental splint the dentist takes an impression of the teeth and alveolar processes with the modeling composition sold by dental supply houses and from this impression as a mold he makes a plaster-of-Paris cast of them with the deformity, if any, reproduced and the line of fracture showing plainly. He then makes a similar plaster cast of the upper teeth and gums. The cast of the lower jaw is next cut through along the line of fracture and the plaster teeth of both fragments are articulated in their normal position with those of the reproduced sound upper jaw. While in their corrected position the cut plaster fragments are fastened together with liquid plaster. Thus the fracture has been reproduced and then corrected in the plaster cast. The interdental splint of vulcanite is then made from these plaster casts of the upper and lower jaws while they are held in a dentist's articulator. The splint is made to hold the upper and lower jaws a little separated and a hole is made in it between the upper and lower teeth through which a rubber feeding tube may be passed and through which liquids may be sucked or expelled. If teeth have been lost the space formerly occupied by them may be used to give access to the mouth by the food and mouth washes.

The splint of vulcanite in favorable cases may be fitted over the lower teeth only, leaving a smooth surface above. It is then wired securely to the lower teeth in several places, retaining the fragments in position and allowing the patient to chew upon it.

Fracture of Ramus of Jaw.—Deformity from this cause is more difficult to treat than that following fracture of the body of the bone. The interdental splint is inapplicable here. The deformity is usually caused by the posterior fragment slipping forward and the anterior fragment falling more or less downward. To reduce it, the operator's thumb in the mouth pushes the ramus backward and the fingers externally lift up the border and body of the jaw. General anesthesia may be required. A stout leather or xylonite chin-piece (see Fig. 16), molded while wet to the shape of the jaw, is applied after reduction and held in place with straps somewhat in the manner of a four-tailed bandage. The pull on these straps must be frequently regulated by the surgeon for even after a good position is obtained the fragments are apt to slip out of place. If the position can be maintained for 10 days or 2 weeks the result will be good.

Comminuted Fracture of the Jaw.—If fractured in more than one place there will be much difficulty in keeping the deformity reduced. If the body of the jaw be fractured in 2 places an interdental splint may yet be successful. If there be a fracture of the body and of the ramus, the interdental splint should be used in combination with the external chin-piece. (Fig. 16.)

Fracture of Coronoid or Articular Process.—Such a fracture is treated by the four-tailed bandage or leather chin-piece and straps, which should be adjusted frequently enough to maintain rest of the fragments.

General Treatment.—When the function of chewing is interfered with for any considerable length of time, the mouth becomes very foul. Add to this the fact that fractures of the body of the jaw are frequently compound and it will be seen how important it is for the surgeon to insist upon frequent and careful cleansing of the mouth. Peroxid of hydrogen diluted with equal parts of water should be used at least twice a day and may be followed by a very dilute solution of tincture of iodin or Seiler's solution. Not only should the mouth be rinsed out but the sulci between gums and cheeks must be brushed or swabbed and the interdental splint if used must be cleansed with a soft tooth-brush. Liquid nourishment is taken through a tube while the jaw is immobilized. If necessary, a rubber tube may be passed behind the posterior molar teeth and the food introduced in this way.

Necrosis along the line of fracture is not uncommon and a resulting abscess of the jaw must be opened and drained according to general principles of surgery. Detached fragments of bone or sequestra should be removed as soon as recognized.

The general health must be kept in view and the patient's habits regulated.

LUXATION OF THE LOWER JAW

In treating dislocation of the jaw it must be remembered that efforts at reduction by simple upward pressure of the chin cannot succeed because this tends to move the condyle farther from its articular cavity. Until it reënters that cavity, hinge motion and closure of the mouth cannot take place.

Treatment.—With the patient preferably in the sitting posture, and with his head firmly held by an assistant, the surgeon stands in front of and facing him. The operator's thumbs should be enveloped in one or two thicknesses of adhesive plaster to prevent their laceration by the bite as reduction takes place and the jaw snaps shut. The thumbs are introduced into the patient's mouth, palmar surfaces down and pressing upon the lower molars while the fingers grasp the border of the lower jaw outside the mouth. Firm pressure should be made downward and while this is going on posteriorly, the symphysis is elevated so as to throw downward and backward the condyle which is drawn into its socket by the pull of the masseter and temporal muscles. Reduction usually occurs with a snap and when it does the surgeon must quickly extricate his thumbs to prevent their being bitten.

Where one condyle only is dislocated the treatment is the same except, of course, that only the affected side is manipulated.

While dislocations of long standing are sometimes capable of reduction in the above-described manner they usually require the use of an anesthetic in order to relax the muscles sufficiently to make reduction possible. For this purpose nitrous oxid gas and oxygen will generally suffice and it would seem that patient and surgeon were entitled to its aid even in the simpler cases.

SUBLUXATION OF THE JAW

Subluxation or sudden locking of the jaw while the teeth are slightly separated is due to a slipping backward of the interarticular cartilages. The condyles are thus pushed forward against the articular eminences. The efforts of the patient often succeed in reducing this dislocation which is likely to recur habitually. If the patient has been unsuccessful, the surgeon can usually reduce the deformity by prying the mouth open by the aid of a hard wooden or bone wedge inserted between the teeth, while an assistant manipulates the jaw, pressing downward and backward and rocking the jaw from side to side.

After a dislocated lower jaw has been reduced a four-tailed or Barton's bandage is applied for a week or 10 days in order to keep the joint at rest while the capsule is healing. The patient should be instructed to exercise especial care not to open the mouth widely for at least 3 weeks after reduction healing may be completed in the opening in the capsule through which the condyle escaped.

Irreducible dislocation of the jaw is treated under general anesthesia with the assistance of McGraw's hook, a stout steel instrument with a handle allowing it to be pulled upon strongly. The hook is passed through a small incision just below the zygoma and over the edge of the sigmoid fossa of the jaw. When properly placed, the hook is pulled downward and backward with considerable force, while an assistant steadies the symphysis and presses it upward. If necessary, the hook is then used in a similar manner upon the opposite side.

DISEASES OF THE BONES OF THE FACE

ANKYLOSIS OF THE JAW

The method of treatment will depend upon the nature of the ankylosis which may be either fibrous or bony and due to conditions either within or outside of the joint. An X-ray picture of the parts which may throw light upon the condition should be obtained in every instance before operation. Fibrous or bony ankylosis existing within the joint is amenable usually to relief by excision of the condyle.

Operation. Gwathmey's method of rectal oil-ether anesthesia is indicated when practicable, as in other operations about the face. Especial attention must be given to the patient's breathing while under the anesthetic. If the tongue is inaccessible by reason of the fixed closure of the jaw, the surgeon must be prepared to perform tracheotomy should the prolapsed tongue or vomitus seriously embarrass respiration. If there is a small space between the teeth a stout silk ligature should be passed through the tongue before operation so that it may be drawn forward if necessary.

The facial nerve which emerges upon the face at the level of the lobe of the ear, the internal maxillary artery and the parotid gland must be avoided during the operation.

Roe and others use an incision extending downward from a point a little in front of the external auditory meatus, and Murphy of Chicago advocates an incision extending upward into the hair from a point over the tubercle of the zygoma and ½ inch in front of the auricle.' Access to the joint is perhaps best obtained by H. Lilienthal's method which is essentially as follows:

LILIENTHAL'S METHOD (See Fig. 17).—A horizontal incision is made along the zygoma from a point ½ inch in front of the auricle. This is joined to a 1½ inch vertical incision downward from its posterior end dividing the skin only. The triangular skin flap is dissected up and retracted downward and forward. A curved needle bearing a silk suture is passed under the posterior end of the zygoma and out again immediately above it, from below upward and backward. The needle should enter at the anterior aspect of the tubercle of the zygoma. A fine wire saw is drawn through the path made by this thread and another at the anterior end of the arch of the zygoma in a similar manner except that here the needle passes under the zygoma from below upward and forward. Thus the excised piece of the zygoma makes a wedge-shaped fragment with its narrow aspect below. This bone fragment is drawn strongly forward, bringing with it the attached fibers of the masseter muscle and other soft parts including a portion of the parotid gland. The retraction of this flap simultaneously with that of the posterior and upper wound edges will afford good access to the joint.

The condyle is freed with a periosteal elevator and its neck is chiseled through with especial care to avoid injury to the external auditory canal. The condyle is removed and if there remains any bony surface to which the neck of the jaw seems likely to become united, a pedicled flap of temporal fascia is sutured in a position which will interpose it so as to prevent this from taking place.

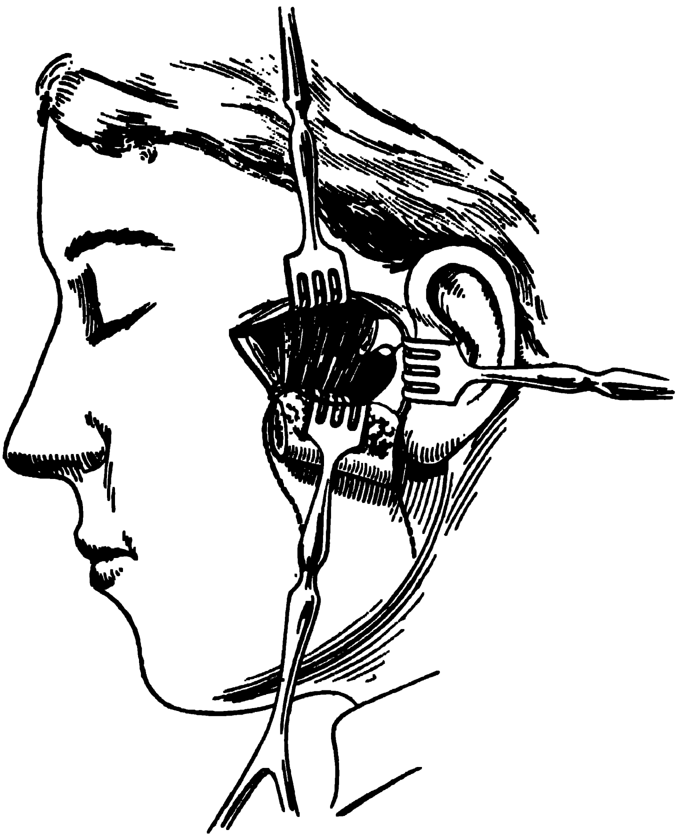

FIG. 17.—H. LILIENTHAL'S INCISION, GIVING ACCESS TO TEMPORAL MAXILLARY JOINT.

The zygomatic bone-flap is replaced and the pull of the masseter will retain it in position, or, if necessary, it may be retained by periosteal or bone sutures. The skin wound is sutured in the usual manner.

If the ankylosis was on one side only, this operation will have unlocked the jaw and have allowed free motion. If the opposite side be similarly affected it will, of course, require operation before the mouth can be opened.

The possibility of bony union between the coronoid process of the jaw and the temporal bone must not be forgotten. Such an attachment must be

separated and a fascial flap must be sutured in place between the severed bone surfaces to prevent a recurrence.

ESMARCH'S OPERATION.—When ankylosis of the jaw is due to conditions outside of the joint, such as cicatrices or contractures about the ramus of the jaw, Esmarch's operation may be called for. (See Fig. 18.)

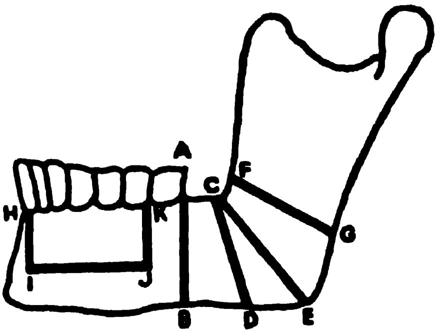

FIG. 18.—LINES OF INCISION IN RESECTING OPERATIONS UPON LOWER JAW.

A wedge-shaped piece of bone is removed extending through the whole body of the bone A B and C D or even one from the lower part of the ramus C E and F G, provided it be wholly anterior to the cicatricial or other cause of the abnormal fixation of the joint. This wedge-shaped piece has its wider aspect below and is large enough to permit free separation of the adjoining bone surfaces so that they cannot again become united to each other and cause a recurrence of the fixation. A false joint is thus formed allowing limited motion of the rest of the jaw. The operation may be performed through an incision along the lower border of the jaw or through the mouth. The fragment is bared and chiseled. The external wound, if there is one, is sutured and drainage into the mouth is kept open and free. Frequent cleansing of the mouth must be attended to.

Phosphorus Necrosis of the Jaw

Phosphorus necrosis almost always occurs in the lower jaw and is caused only by the yellow form of the element.

Prophylaxis.—The manufacturers of matches whose employees formerly suffered widely with this disease have amended their processes of producing matches in this country very generally and have substituted harmless materials. The disease will, without doubt, become more rare in the future.

The patient should work with the red or amorphous form of phosphorus. He should wash his hands carefully before eating so as to avoid contaminating his food. Inspection of the teeth and gums of phosphorus workers should be made by a competent physician at regular intervals. Carious teeth must be repaired or extracted and if ulceration of the gum has begun the patient must avoid all contact with phosphorus and carry out careful and persistent cleansing of the mouth. A soft tooth-brush should be used with an antiseptic tooth-powder or paste and the mouth washed after each meal. There is no better combination of measures for this purpose than a preliminary rinsing with equal parts of hydrogen peroxid and water followed by the free use of a watery solution of tincture of iodin diluted to the color of light beer. This has astringent and antiseptic qualities.

Operative Treatment.—In advanced cases a radical operation is to be preferred to the ancient custom of waiting for the separation of a sequestrum. The patient should forever abandon contact with phosphorus.

The affected portion of the jaw is excised as is described under the various headings of excision and resection of the jaw and its parts. The aim in operations for removal of the sequestrum or any diseased bone is to leave in place as much healthy periosteum as possible as a base for the regeneration of the lost osseous tissue.

INFECTIONS OF THE BONES OF THE FACE

Acute periosteomyelitis of the upper or lower jaw following carious teeth or from blood-borne infections, is treated by incision and drainage in the same manner as when occurring in other situations. The only especial feature which characterizes treatment of bone inflammations in the face is the added necessity of cosmetic considerations. Drainage, when called for, should be established through the mouth if possible but when external drainage is necessary the incision should be made in the line of cleavage of the skin (see Normal Incisions) so as to leave an inconspicuous scar.

Necrosis.—The general principles of treatment of sequestra of the facial bones are similar to those of like conditions elsewhere, except that they are modified by one important symptomatic fact. This is that after destruction by necrosis of bone in the upper jaw and in the lower jaw in all but young patients there is no reproduction or formation of an involucrum as there is in the case of other bones. Hence there is added necessity for early treatment of bony inflammations of the jaws so as to avoid disfigurement of the patient. After the defect has occurred the possible use of prosthetic apparatus to remedy it should be inquired into.

Syphilis.—Syphilis of the bones of the face is usually found affecting the nasal bones and the upper jaw, causing the characteristic saddle nose of the tertiary stage and the opening between the mouth and nares. (See Diseases of the Nose and Mouth.)

Tuberculosis.—Tuberculosis of the bones of the face occurs usually in the malar bone or upper jaw. The treatment is constitutional according to the recognized principles and if an abscess forms it should be opened by an incision in the natural line of cleavage of the skin (see Normal Incisions) and the diseased bone thoroughly curetted. If this is done early, the characteristic depressed scar beneath the orbit may be avoided.

TUMORS OF BONES OF FACE

EXOSTOSIS OF FACE AND SCALP

These benign growths are very rare upon the face but not uncommon upon the skull. The only indications for their removal are disfigurement and inconvenience. The tumor is of pure bony structure and of very slow growth. Sections should be made for examination under the microscope to determine the existence of possible indications of malignancy.

Operation.—General anesthesia is required. The skin and soft parts over the tumor are incised in the normal line (see Normal Incisions) so as to expose the whole bony growth. This is then chiseled away with its periosteum and the wound is closed with sutures and dressed as in the case of other operations for removal of growths of the face and scalp.

Malignant Growths of the Bones of the Face

Malignant growths of the bones of the face demand early and thorough excision. If the skin and subcutaneous tissues are involved, plastic surgery will be necessary to repair the deformity after their removal by the knife. This subject is treated of elsewhere in this work.

The following descriptions of operations upon the bones of the face describe the surgical treatment of malignant growths of those bones as well as of necrosis from various causes.

OPERATIONS UPON THE BONES OF THE FACE

Excision of the Upper Jaw

The anesthetic for this operation is administered by the intratracheal method and the pharynx may be lightly packed with a gauze pad. The patient lies supine with the head somewhat elevated. A gag keeps the mouth open widely enough to afford access to the mouth cavity for the operator with his instruments and for the assistant with sponges to clear the field of operation, retract, etc. The operation is greatly simplified by a preliminary ligation of the external carotid artery. (See Ligation of Arteries in another part of this work.)

Access to the bone is obtained by an incision through all the soft parts in the following course (Weber) (see Fig. 19, A, B, C): From a point about half an inch below the outer angle of the orbit, the incision follows along its lower border inward to the nose, then downward to the wing of the nose, around the groove at the junction of this wing with the face and to the median line at the septum of the nose, thence vertically down through the upper lip in the median line. Bleeding of the wound edges is checked with ligatures and the cheek is dissected up from the bone with a periosteal elevator. The line of junction of the mucous membrane lining the cheek with that of the alveolar process is divided with curved scissors. This cheek flap is retracted with a stout suture through the cut edge of the lip and held back by an assistant so as to give a fair exposure of the outer surface of the upper jaw bone in-

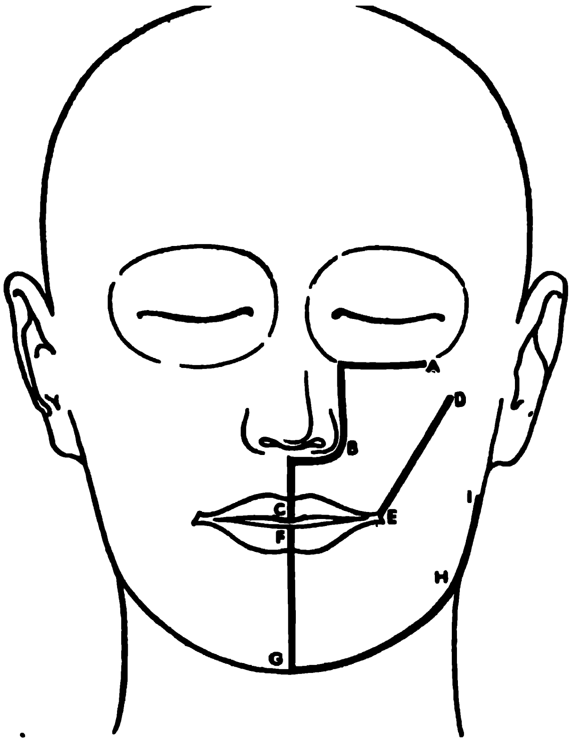

Fig. 19.—Lines of Incision in Soft Parts of Face in Various Operations upon Its Bones.

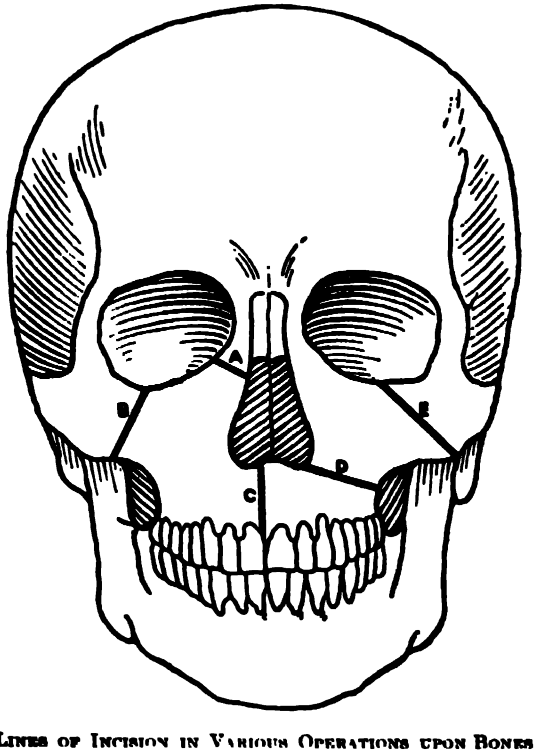

Fig. 20.—Lines of Incision in Various Operations upon Bones of Face.

cluding its malar process. An elevator or knife separates the lower edge of the nasal cartilage from the bone and if the bleeding is serious at this point the nostril is temporarily packed with gauze while the next steps of the operation are under way. The malar process of the bone is divided from within outward by a wire saw which has been passed through the inferior orbital (sphenomaxillary) fissure. Considerable latitude is possible in directing this division B or E (Fig. 20) of the bone and, where the limits of the disease process permit of it, the excision should end externally as far toward the middle line as possible, so as to leave support for the cheek and thus minimize the subsequent deformity.

The nasal packing is now removed and the nasal process of the upper jaw is cut away from the nasal bone with the bone-cutting forceps, while an assistant retracts the inner edge of the skin wound with a sharp retractor.

With the gag on the sound side, the mouth is widely opened in order to give access to the roof of the mouth. With the scalpel he cuts through the mucous membrane and down to the bone along a right-angled course extending from the posterior molar tooth to the middle line of the hard palate and from thence forward directly to the space between the central incisor teeth. (Fig. 21, O, N, M.) A periosteal elevator is then introduced into the transverse part of this incision and separates the soft palate from the hard palate, pushing the former back out of the way. The central incisor tooth on the affected side is next extracted. A chisel introduced within the mouth then cuts through the hard palate from before backward near the median line as far as the transverse incision. If necessary the chisel may be assisted by the forceps or a narrow-bladed saw, or the whole cut through the palate may be made with a chain or wire saw passed through the nose and out of the mouth.

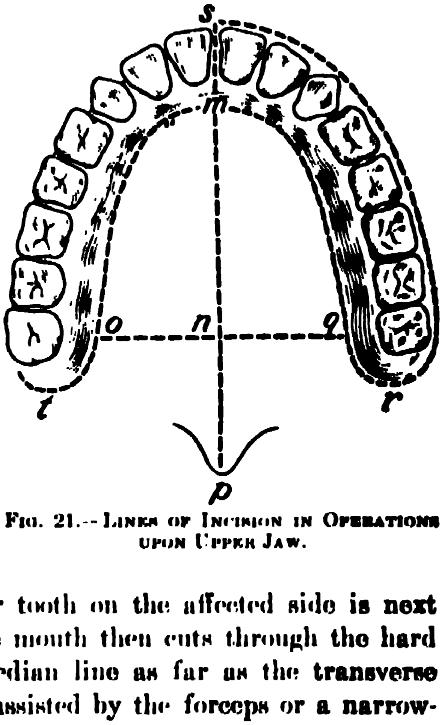

FIG. 21.—LINES OF INCISION IN OPERATIONS UPON UPPER JAW.

The bone is now ready to be removed as all its attachments are divided save that to the palatal bone behind and to the ethmoid bone above. These attachments are broken by grasping the whole upper jaw bone in a lion-jaw forceps and rocking it up and down and from side to side. The superior maxillary nerve in the infraorbital fissure will be among the soft parts yet undivided when the bony attachments are all severed. This nerve is cut across as near its origin as possible.

The transverse incision in the mucous membrane between the hard and soft palates is sutured with silk as well as that on the posterior surface of the upper lip. The skin incision is sutured with silk and the cavity packed with sterile gauze.

If the mucous membrane of the hard palate is not diseased it should be left to separate the nasal from the buccal cavity. In this case it is cut through along the inner edge of the alveolar process close to the teeth (Fig. 21, O, M, or Q, M) instead of along the median line. It is separated from the bone back to the median line and retracted while the palate is being chiseled or sawed through. Afterward its edge is sutured to the edge of the mucous membrane of the cheek. (See Subperiosteal Resection of the Upper Jaw.)

A copious sterile gauze and cotton dressing is applied to the face and held in place with adhesive strips and bandage. The mouth is frequently irrigated and the packing changed often enough to prevent its fouling. Rest in bed but in the semi-recumbent or sitting posture and a liquid diet are necessary for a week or more and opiates are given, if needed, until the healing process is well advanced. When healing is complete, a prosthetic apparatus should be prepared if the circumstances permit. This is done by a competent dentist to supply the defect caused by the removal of the bone.

SUBPERIOSTEAL RESECTION OF THE UPPER JAW

Subperiosteal resection of the upper jaw is performed in cases where the disease of the bone has not invaded the periosteum. The anesthetic of choice is ether given intratracheally.

Access to the bone is had by Ollier's incision combined with median division of the upper lip. Ollier's incision (Fig. 19, D, E) extends from the center of the malar bone to the outer angle of the mouth. Traction upward is made upon the cheek flap, while the periosteum along with the overlying soft parts is separated and elevated from the bone. An incision through the mucous membrane and periosteum is made (see Fig. 21, S, X, M) from the median line in front, along the outer surface of the alveolar process, just above the edge of the gum, to the last molar tooth. It is continued around behind this and then forward at the same level along the posterior surface of the alveolar process to the median line opposite the starting-place. The periosteum is divided by a cut beginning at the starting-point of the first incision and extending up to the anterior nasal spine. The periosteum and other soft parts together are stripped back with a periosteal elevator from the outer surface of the jaw. The infra-orbital nerve and vessels are divided and the baring of the bone is continued to and over the edge of the orbit well back along the floor of the latter. The lacrimal sac and duct are avoided and left intact with the periosteum.

The periosteum is separated with the mucous membrane from the hard palate as far as the median line. As in the usual operation described above, the nasal and malar processes of the upper jaw bone are divided, the central incisor extracted and the hard palate chiseled or sawed through as nearly as may be in the median line. Lion-toothed forceps are then used for grasping the bone and wrenching it as gently as possible from its attachments. The cavity is packed with a wick of sterile gauze and the edges of the mucoperiosteal flaps are united where they had been separated by the teeth. The skin wounds are sutured with silk and a dressing of sterile gauze is applied under a bandage. The packing is removed and loosely replaced after 3 or 4 days. The wound cavity is irrigated and the packing is changed often enough to keep the parts clean and the patient comfortable until healing is completed, when a competent dentist may be called upon to supply a prosthetic apparatus to fill the defect caused by the removal of the bone.

Resection of the Upper Part of the Upper Jaw

The bone is exposed as described under Excision of the Upper Jaw. The soft parts are separated over the outer surface of the bone and well back upon the orbital plate. The nasal and malar processes are cut through as described above and the jaw bone itself is cut through horizontally above the alveolar process with a narrow saw introduced into the nares. (Fig. 20, D.) The upper segment of the bone, thus partially detached, is then grasped with lion-jaw forceps and wrenched out.

The cavity is packed with sterile gauze which is removed in 2 or 3 days. Irrigation of mouth, nares and the wound cavity is done frequently with weak Dobell's or Seiler's solution.

Excision of the Lower Jaw

Excision of the lower jaw or portions of it is performed for the removal of tumors, necrosis, gunshot wounds, etc. A complete resection is rarely called for. The operation should be conservatively done and the amount of bone removed will vary with the needs of the individual case.

The anatomy of the region must be mastered and care taken to avoid so far as possible injury to the parotid and the submaxillary glands and their ducts, the internal maxillary arteries and the lingual and facial nerves.

When the body of the bone is removed, the anterior supports of the tongue fail to hold it forward and it drops back into the pharynx and obstructs respiration during anesthesia unless retracted by a suture in the hand of an assistant.

Mucous membrane and periosteum, where they are healthy, should be stripped from the bone to be removed and left remaining, to be afterward sutured in place as well as possible. If the operation is for a malignant growth, however, these soft tissues must be sacrificed in the effort to eradicate the disease.

RESECTION OF HALF OF THE BODY OF THE JAW

The incision extends along the lower border of the jaw to the (Fig. 19, H, G, F) median line where it ascends to or through the lower lip. The facial artery is ligated. (See Ligation of the Facial Artery.) Teeth whose presence interferes with the use of the saw are extracted. The soft parts, including periosteum if the case be not malignant, are stripped from the bone over its inner and outer aspects so far as the individual case may require. This stripping extends up to an incision made down to bone along the edge of the alveolar process. If a bridge of bone along the bottom (see Fig. 15) can be left standing it will be of great advantage to the patient in preserving the form of the jaw and the opposition of the remaining lower teeth with the upper ones. If this bridge of bone is left it is separated from the excised portion with the chisel. The 2 vertical cuts in this case, of course, do not extend downward to the lower border of the bone, but only far enough to connect with the horizontal cut in the jawbone. (Fig. 18, H, I, J, K.) The flaps of mucous membrane formerly covering the alveolar process are trimmed and their edges are sutured together. If the whole thickness of the body of the bone has been cut through, that portion of the mucous membrane formerly covering the outer surface of the alveolar process is trimmed away and the inner flap is sutured directly to the edge of the lining of the cheek.

Drainage is provided for and the skin wound sutured. A four-tailed bandage holds the dressing in place. The essentials in the after-treatment are rest, liquid diet, and frequent cleansing of the mouth.

EXCISION OF A RAMUS AND HALF OF THE BODY OF THE LOWER JAW

The incision F, G, H, Figure 19, is continued along the border and up the edge of the ramus of the jaw to a point, H, just below the lobe of the ear. The facial artery is ligated where severed by this incision. The soft parts en masse are dissected up from the outer surface of the bone, separating the insertion of the masseter as far as possible without entering the cavity of the mouth. Periosteum is included in this denudation as well as in that which is to follow upon the inner aspect of the bone, provided the operation is done for the treatment of necrosis, but in the case of malignant disease the periosteum must be removed with the bone. When the flap is separated from the bone it is strongly retracted upward and forward during the remaining steps of the operation. At the point near the symphysis where the body of the jaw is to be cut through, a tooth is extracted in order to permit the saw to enter and cut through the body of the jaw. The bone is grasped with a lion jaw forceps and pulled downward and outward while its inner surface is denuded from below upward with periosteal elevator and knife or scissors.

A ligature is passed through the tongue and forward traction upon this is made by an assistant to prevent the organ from falling back into the pharynx and obstructing respiration. This complication is inevitable if the anterior attachments of the tongue to the genial tubercles are severed as they must be if the middle of the jaw is to be removed. The inferior dental nerve and artery will be severed at their entrance to the interior dental foramen during the denudation of the inner aspect of the jaw.

The attachment of the temporal muscle to the coronoid process is cut through and the condyle is disarticulated from the glenoid cavity. The remaining attachments of soft parts are carefully cut through.

After removal of the bone the mucous membrane is sutured in the mouth where it was formerly attached to the edges of the alveolar process and wherever else it may have been divided. The cavity left by the removal of the jaw is lightly packed and drained with sterile gauze, the skin sutured and sterile dressings and bandage are applied. The same necessity for cleansing of the mouth exists as after excision of the upper jaw. (See page 573.)

THE TREATMENT OF FRACTURE OF THE SKULL

CHAPTER IX

THE TREATMENT OF FRACTURE OF THE SKULL

WILLIAM SHARPE

INTRODUCTION

Palliative Treatment.—For many years the routine treatment of fracture of the skull, whether of the base or of the vault, has been the expectant palliative one; that is, an ice-bag to the head, vigorous catharsis, liquid diet, and absolute rest and quiet, morphia being administered if necessary. Practically all fractures of the base were so treated, it being thought that nothing else could be done for such cases; the mortality was high—more than 50 per cent. Even depressed fractures of the vault, unless there were localized signs of compression, were frequently treated in the same manner.

Naturally, the cases of simple concussion and the mild fractures of the skull —and I believe that many cases of fracture of the skull are overlooked on account of their comparatively trivial symptoms and signs—have been and are being treated successfully by this method; it is, however, in those cases of fracture of the skull, whether of the base or of the vault, with or without a depression of fragments, where there are definite signs of an increased intracranial pressure, that this expectant palliative treatment is not sufficient and a more effective method of treatment is essential.

Intracranial Pressure.—Within the last few years a notable advance has been made in the treatment of these cases. In my opinion, it is not so much a question of ascertaining the presence and the site of the fracture, but rather of finding out whether or not there is an increased intracranial pressure, and if there is, then directing the treatment toward a lowering of this abnormal pressure. For this reason, a careful ophthalmoscopic examination should be made in each case, as the earliest signs of an increased pressure appear in the fundus of the eye, especially about the entrance of the nerve—the so-called optic disk.

These changes in the fundus of the eye are the result of increased intracranial pressure, whether this pressure be due to a slowly growing tumor, to an intracranial hemorrhage, or to a very edematous "swollen" brain resulting from a fracture of the skull. It is this cerebral edema, resulting in varying degrees from any injury to the brain—from the mild conditions of concussion to the worst forms of cerebral contusion and laceration—which has been overlooked in the past; in my opinion, it is the most important factor to be considered in any case of fracture of the skull. In the mild cases, only a slight dilatation of the retinal veins results from the intracranial pressure due to this cerebral edema, and the veins gradually assume their normal size and appearance within 2 to 4 days, showing that the intracranial pressure has diminished through the absorption of the edema, i. e., a more normal amount of intracranial cerebrospinal fluid.

The success of the expectant palliative treatment in these mild cases is based upon the fact that by it not only is the absorption of cerebrospinal fluid increased, but the amount of cerebrospinal fluid secreted is lessened by the lowering of the blood pressure; the tendency to intracranial hemorrhage is also lessened. Naturally, the sooner after the accident the treatment is started, the better are the results to be obtained.

In the more severe cases, however, a more direct method of lowering this increased pressure is necessary; I use the word "severe" not so much in reference to the fracture as to the height of the intracranial pressure. These are the cases showing not only a dilatation of the retinal veins, but also a blurring of the nasal halves of the optic discs and the more advanced signs of intracranial pressure to be observed with an ophthalmoscope. Such cases, in my opinion, should have a subtemporal decompression performed to relieve the intracranial pressure as soon as possible after the accident. If, however, the patient is in a condition of severe shock, so that its signs overshadow and tend to conceal the signs of intracranial pressure, then all treatment should be directed toward relieving the condition of shock, and when this has been accomplished, then the lowering of the intracranial pressure can be considered. I do not think it wise to decompress any fracture of the skull in a condition of severe shock and with a pulse rate of 110 or more. The operation itself is not a formidable one; naturally, perfect asepsis is essential. The anesthesia should be administered by an expert; only too frequently, however, the patient is unconscious, so that an anesthetic is not required.

Palliative vs. Operative Treatment.—In too many hospitals the attitude toward fractures of the skull, and especially those of the base, has been one of expectancy, a policy of "letting well enough alone;" unless there were localized signs of compression, then an ice-bag to the head, catharsis, absolute rest and quiet, and the usual routine treatment were given; any operative procedure was not to be considered unless the patient developed signs of compression of the medulla—slow pulse, 50 or below, irregular respiration of the Cheyne-Stokes type and a blood pressure of 170 or more. Then and only then would an operation be advised and performed, with the usual result—the death of the patient. Several days may elapse before the signs of medullary compression occur, but once the signs of medullary edema and collapse do occur, an operation will save only a small percentage of cases—less than 10 per cent. The time for the operation should be judged according to the amount of intracranial pressure as shown by the ophthalmoscope, and not by the extreme signs of medullary compression. This method of not operating until signs of medullary compression occur, i. e. the signs resulting from the most extreme degree of increased intracranial pressure, accounts for the high mortality of operations performed at this late period, and justifies the opinion of so many observers in the past that the expectant palliative treatment of fractures of the skull is equally as successful as the operative treatment. Patients, however, should not be permitted to reach this dangerous condition of medullary compression, as its forerunner, high intracranial pressure, can always be revealed by the routine use of the ophthalmoscope. Besides, an early decompression will not only save the lives of a large percentage of patients who otherwise would have died from medullary compression, but it will lessen the percentage of posttraumatic conditions so frequently following fractures of the skull: in the mild cases, those vague indefinite headaches, associated at times with dizziness, a throbbing sensation in the head, and the early signs of fatigue, so commonly observed and considered as posttraumatic neuroses; in the more severe cases, a complete change of personality the patient becoming either very irritable and restless, indulging in fits of anger at the least provocation, and having so little self control that he is unable to hold any position permanently; or the reverse, very much depressed with loss of ambition, a "happy-go-lucky," and in many cases, as relatives have expressed it, a "bum" and "good-for-nothing." Epilepsy — especially petit mal, and at times grand mal — is fairly common after fractures of the vault, but rather rare following basal fractures (due possibly to the resulting hemorrhage being at the base and not over the cortex).

Such has been the result of my following the histories of patients who have had the usual fractures of the skull, particularly of the base, and have been treated by the expectant palliative treatment in 3 of the large hospitals in New York City since 1900. These cases remained in the hospital during periods of 2 to 6 weeks, and were almost without exception discharged as "well" or "cured." Naturally, it has been a most difficult undertaking to locate these patients, especially after a lapse of 5 years or more, and particularly since the vast majority of these cases are the usual ambulance patients of the poorer classes who change their residences almost as frequently as the seasons come and go. My inability to locate more than 34 per cent. of them may thus be explained. The most striking thing, however, is that of the cases found, 67 per cent. are still suffering from the effects of the fracture of the skull; that is, they have not had the same good health since the accident as before, the most frequent complaints being headaches of greater or less severity, changes in personality of the exalted and of the depressed types, a nervous instability, and occasionally epilepsy in its various forms. That is, over half of the cases I was able to locate were not well. It is for this reason, no doubt, that it is popularly believed that, "once a person has had a fracture of the skull, he is never the same again"; these statistics tend to confirm this belief.

The cases which were operated upon in these hospitals were mostly depressed fractures of the vault; in those cases of fracture of the base which were operated upon, the operation was performed only in the cases showing signs of definitely localized compression and of medullary edema, and naturally the mortality was very high—being 87 per cent. Besides, a bone flap operation was frequently performed and the bone flap then replaced, thus lessening and even preventing the benefits of a decompression; in some cases the dura was not opened and, therefore, the benefits of a decompression could not be obtained, because the dura is inelastic in adults; it must always be opened if a decompression is desired. Simply removing an area of the bony vault is not a decompression.

Of those cases of fracture of the base which were decompressed at the Johns Hopkins Hospital since 1900, 58 per cent. were located, and of this number only 32 per cent. are suffering from the effects of the fracture; of the cases operated upon since 1906, only 22 per cent. are still impaired, due undoubtedly to the earlier operation on the service of Dr. Harvey Cushing.

My experience in hospitals of New York City and Boston where the expectant palliative treatment was adhered to in fracture of the base, and then in another hospital in Baltimore where such cases were operated upon early, has strongly impressed me with the superiority of the latter treatment. Since then, I have advised operation upon cases of fracture of the skull as soon as definite signs of a marked increase of intracranial pressure can be demonstrated by the ophthalmoscope, and the results have been most gratifying. Not only is a medullary edema avoided by an early operation and an immediate relief of the intracranial pressure obtained, but the percentage of the posttraumatic conditions, both physical and mental, has been very much lessened.

In my series of 51 operated cases (to June 1, 1914), the percentage of those patients still suffering from the effects of the intracranial pressure resulting from the fracture of the base is 12 per cent.; these were the extreme cases having cortical lacerations and numerous small hemorrhages in the cortex, as revealed at the operation. Naturally, sufficient time has not yet elapsed to render these figures regarding the posttraumatic conditions of greater value, and it will be necessary to wait at least 5 years in order to obtain more accurate data regarding them.

Naturally, I do not advise a decompression in all cases of fracture of the skull, but only in those showing marked signs of increased intracranial pressure. Fortunately, it is a fairly frequent occurrence to have a fracture of the skull (confirmed clinically and by the X-ray) with no marked signs of intracranial pressure; in these cases a decompression can do no good and would be only an added risk. But, in cases showing marked signs of increased intracranial pressure, the early relief of this pressure is essential, not only to lessen the percentage of the posttraumatic conditions, but to avoid a medullary edema and its resulting high mortality.

TYPES OF FRACTURE OF THE SKULL

Fractures of the skull may be classified briefly according to their location; direct fractures occurring at the immediate area of contact, and the "indirect" fractures occurring at various distances from this area of contact.

I. **Direct Fractures.**—The direct or local fractures may consist of a break either of the outer or of the inner table of the skull, or of both if the impending force is sufficiently strong. If the surrounding outer table is broken, a partially depressed fracture may result; if the surrounding inner table is also broken, then a completely depressed fracture is possible; if more than one fragment is present, the term "comminuted" fracture may be used. (Figure 1 demonstrates the various degrees of direct fractures.) Eight of my operated cases represented different degrees of direct or local fractures.

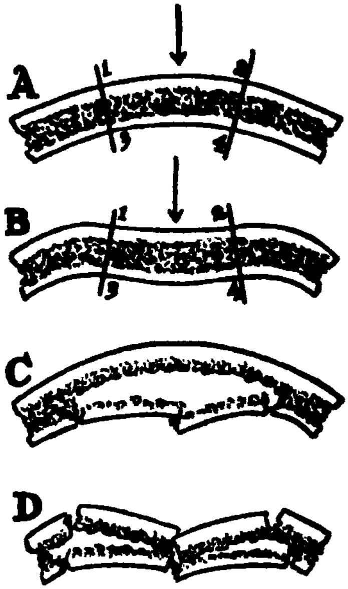

Fig. 1.—Local Depressed Fractures of the Vault; the Mechanics of Their Production. A, the normal vault with its outer and inner table, and the interposed diploë. The arrow indicates the force applied at the point of contact, and the lines 1—3 and 2—4 are placed at right angles to both the outer and inner tables; naturally they converge. B, the force applied at the point of contact produces a depression of both the outer and inner tables, and especially of the inner table, as shown by the divergence of the lines 1—3 and 2—4. C, the inner table may fracture and a fragment may be depressed, and yet the outer table may remain intact, either depressed or, as illustrated here, in its original position. D, a complete depressed fracture occurs when the force applied is sufficient to cause a fracture not only at the point of contact but also at the margin of the depressed area; the line of fracture of the inner table is always beyond that of the outer table.

II. **Indirect Fractures.**—The indirect fracture is usually a linear one—extending away from the area of contact and most frequently down into the base of the skull, especially into the middle fossa. My experience has been that it is rare for a fracture to be limited to the vault alone, whether the fracture be a simple linear one—a "crack"—or one with depression; it will usually be found that a line of fracture extends from the thicker bone of the vault down to the thinner bone of the base, and this is what we naturally would expect. Thirty of my operated cases were of this type.

Many theories have been evolved to explain this tendency of fractures to radiate to the base. It was a common observation that if the cranial vault was struck by a fairly pointed object, then a localized depression or even a perforation would result, and possibly a line of fracture would extend downward into the base; however, if the cranial vault was struck forcibly by a blunter, wider surface, then there might not only be a localized depression, but a line or lines of fracture would extend downward into the base and up the opposite side—the lines of fracture tending to merge at a point directly opposite the area of contact by the object. This radiation of the lines of fracture and their tendency to merge on the opposite side, producing what has been termed the fracture of "contre-coup," are most satisfactorily explained, in my opinion, by the "bursting" effect of injuries of the cranial cavity. When the head is forcibly struck against a hard object, the point of contact tends to be approximated to its pole on the opposite side, and so mechanically there is a tendency for a line of fracture to occur in one of the meridians extending from the point of contact to its opposite pole; as the base, especially its middle fossa, is much thinner and weaker than the bone comprising the vault of the skull, naturally the line of fracture extends downward into the base and the so-called "fracture of the base" results. The line of fracture may, however, merge into one of the sutures of the vault of the skull, producing the so-called "fracture by diastasis," which frequently occurs in children.

These lines of "bursting" fractures of the skull most frequently extend downward into the middle fossa through the petrous portion of the temporal bone, rupturing the tympanic membrane and thus allowing blood from the middle ear, and even cerebrospinal fluid, to escape at the external auditory meatus. If the line of fracture extends into the anterior fossa, then the cribriform plate of the ethmoid bone, being the thinnest and weakest portion, is usually "cracked," producing bleeding from the nose. Mere bleeding from the nose or from the ears, however, does not necessarily indicate a fracture of the base, because the blood may result from an external injury to the nose itself or to the external auditory canal; if, however, cerebrospinal fluid is also observed, then a fracture must be present. Extreme care should be used in ascertaining a rupture of the tympanic membrane because of the great danger of infection; it is much wiser merely to wipe the external auditory meatus with sterile cotton and not attempt to introduce instruments for an otoscopic examination; naturally, if there is no bleeding from the ear, an otoscope can be used without danger of infection and frequently blood in the middle ear will be observed, while the tympanic membrane remains intact.

In my own series of 51 operated cases, the area of contact was in the parietotemporal region in 32, and in 23 of these a line or lines of fracture extended downward into the middle fossa or forward into the angular process of the orbit of the same side. In 38 of the cases of fracture of the base of the skull in which no signs of fracture of the vault were ascertained, in performing a subtemporal decompression, a line of fracture was found extending upward into the vault in 11. Fractures of the frontal region most frequently radiate into the orbital bones and into the anterior fossa, producing marked orbital signs and a hemorrhage and leaking of cerebrospinal fluid into the nasal cavity.

Fractures of the posterior portion of the vault, when they do radiate, frequently send lines of fracture downward toward the margin of the foramen magnum, and occasionally beyond it into the basilar process. This type of fracture is the most serious of all cranial fractures, due chiefly to the great danger of medullary edema resulting from the pressure of hemorrhage or edema beneath the tentorium. The signs of medullary edema usually appear very soon after the injury, and death occurs frequently within 2 hours. A subtemporal decompression in these cases offers what little chance there is for recovery. Four of the operated cases that died revealed at autopsy this type of fracture of the occipital bone and its basilar process.

It is interesting to note that a most common site for direct depressed fractures is in the upper posterior portion of the vault, about the posterior fontanel, and yet the lower occipital area surrounding the foramen magnum is so well protected by large bony buttresses that the lines of fracture radiate most frequently forward into areas of comparative safety rather than backward into the occipital bone beneath the tentorium—a most dangerous area.

SYMPTOMS AND SIGNS OF FRACTURES OF THE SKULL

I. SYMPTOMS (BRIEFLY)

The symptoms of fractures of the skull are naturally few.

A. Headache.—Headache of a "throbbing," "beating" character is practically always present. At times it is only a dull, heavy feeling in the very mild cases, while in the cases which still remain conscious it is very severe and intense—the typical "splitting" headache. The restlessness may be extreme.

B. Nausea.—Nausea is very common, and if the injury has been received 2 or 3 hours after a meal, vomiting may occur. Too much importance, however, has been placed in the past upon the symptom of nausea; in my experience, it is associated with any condition producing shock, whether the injury be cranial, abdominal, or elsewhere. It is no index of increased intracranial pressure, unless extreme and in subtentorial lesions about the medulla.

II. SIGNS

Local Signs.—An accident sufficient to fracture the skull must necessarily injure the outside of the head to a greater or less extent; such contusions must be rigidly excluded in making a diagnosis of fracture of the skull. Ecchymoses about the orbits and mastoid regions, and hemorrhage from the nose, mouth, and ears are frequently the result of local injuries and in no way associated with a fracture of the skull; hematomata of the scalp, especially if subpericranial, may easily simulate depressed fractures of the vault; the reverse is also true, linear fractures of the vault being frequently concealed beneath hematomata. In doubtful cases the head should always be shaved, and an exploratory incision through the scalp should be made to ascertain the true condition; a careful bimanual palpation of the head is very important.

Any bleeding coming from the nose, throat, or ears should always have its source investigated; if cerebrospinal fluid is observed, then a fracture of the skull must be present. Subconjunctival hemorrhages, as well as ecchymoses in the mastoid region appearing soon after the accident, without a local contusion being present, are very indicative of a basal fracture; if these signs appear after 1 or 2 days, they are especially suggestive. It is possible, however, to have a subconjunctival hemorrhage and yet no fracture of the orbital bones.

In severe fractures the leakage of blood and cerebrospinal fluid may be so free that the tissues about the orbits and in the occipital region will become markedly edematous and boggy. A mere ecchymosis of the orbit is of no diagnostic value, since any injury to the anterior portion of the scalp will produce the typical "black eye."

General Signs.—A. PULSE.—Owing to the usual presence of shock, the pulse-rate following a fracture of the skull is frequently 110 and over, and this may continue for several hours until the shock gradually disappears; the pulse will then be lowered to its normal rate, and may become much less. If 60 or below, a definite degree of intracranial pressure is usually present; however, the normal pulse-rate of the patient should always be ascertained. The pulse-rate, unfortunately, is not an accurate means of determining the severity of the intracranial lesion; ordinarily the greater the intracranial pressure and, therefore, the less the blood supply to the medulla, the slower the pulse-rate, but the resistance of the medulla to slight changes in its circulation varies so much in different individuals that it is possible to have a high degree of intracranial pressure and yet a pulse remaining between 70 and 80 for a number of hours; finally, the regulatory mechanism of the medulla may be affected, and then the signs of medullary compression advance unusually rapidly—leading to the quick death of the patient. I have had several cases in which the pulse-rate remained between 70 and 80, and yet the ophthalmoscope revealed marked signs of high intracranial pressure; at operation the high pressure was confirmed, usually due to a markedly swollen edematous brain with numerous punctate hemorrhages in its cortex—the subdural cerebrospinal fluid being blood-tinged.

However, if the pulse-rate is lowered to 60, and especially to 50, we have an excellent danger signal, which should always be heeded. Any further lowering of the pulse-rate is usually associated with irregular respiration of the Cheyne-Stokes type and the prognosis becomes very poor indeed.

As the pulse-rate is lowered, the character of the pulse itself becomes full, strong, and well sustained—apparently an excellent pulse; it is, however, only the attempt of the circulatory mechanism to overcome the partial anemia of the medulla due to the increased intracranial pressure, and to force blood into it. If this condition remains for a variable length of time, signs of medullary collapse—rapid shallow pulse and quick irregular respirations—may occur at any moment, and then death is merely a matter of hours.

B. RESPIRATION.—The respiration, like the pulse-rate, may be affected by shock, and may exceed 30 for an hour or more immediately after the injury. Its rate, however, becomes the normal 20 to 24 much more quickly, and remains normal unless the intracranial pressure becomes so high as to cause the definite medullary signs of a Cheyne-Stokes type of breathing. In such cases the period of apnea or non-breathing may exceed 40 seconds. It seems that the pulse is more easily affected by intracranial pressure than the respiration, and when the latter is influenced, a medullary collapse may occur at any moment.

C. BLOOD-PRESSURE.—It has been most interesting to record the influence of intracranial pressure upon the general blood-pressure in the cases of fracture of the skull. It was surprising to ascertain that rarely was the blood-pressure forced beyond 160, and then only in the cases showing early signs of medullary compression; in these cases the blood-pressure might ascend to 200 with a pulse-rate of 50 and below, and a Cheyne-Stokes respiration, showing an extreme degree of intracranial pressure and one that could not be long sustained by the medulla. These were the cases allowed to wait a number of hours before the decompression was performed, and their recovery was most doubtful. Our operative mortality is very high for cases that have been allowed to reach this extreme degree of medullary compression; signs of a medullary collapse—high pulse-rate of a shallow, poorly sustained character, irregular, shallow respirations, and a blood-pressure of 100 and less usually followed within several hours—operation or no operation.

A number of years ago venesection was considered advisable to lower the increase in the general blood-pressure; von Bergman and Leonard Hill thought favorably of it. However, it is no longer employed because it is now known that this increase in the general blood-pressure is the attempt of the vasomotor mechanism to force blood into the intracranial chambers and thus into the medulla by overcoming the increased intracranial pressure. To bleed a patient, unless in the very mild cases, is thus an exceedingly dangerous procedure and always contra-indicated.

D. PARALYSES.—Unless the fracture of the skull is a depressed one over either motor tract, so that the underlying cortex is compressed and even lacerated, or there is a large extradural hemorrhage (due to a rupture of the middle meningeal artery) and, less frequently, a subdural clot overlying the same area, it is rare for a fracture of the skull to produce paralyses of the extremities. Especially is this true of fractures of the base.

Paralyses of the cranial nerves, especially those controlling the movements of the eyeball—the third (oculi motorius), the fourth (patheticus), and the sixth (abducens)—and also the seventh (facialis), are very common in basal fractures, resulting in ptoses, strabismus, and facial paralyses. If the nerves have been severed, then a permanent paralysis results, but very frequently the paralysis fades away after the local pressure has been removed—commonly by the absorption of a blood-clot.

The other cranial nerves most frequently affected are the first (olfactorius), the fifth (trigeminus), and the eighth (auditorius). The second (opticus) and the other cranial nerves are rarely primarily affected.

Motor aphasia frequently results from subdural and cortical clots overlying the motor speech area of the left third frontal convolution posteriorly; in many cases it is merely a paraphasia.

E. AREAS OF ANESTHESIA.—It is rare for anesthesia to be present. It does occur, however, if the fifth cranial nerve (trigeminus) has been injured, and especially if a large extradural or even a subdural hemorrhage exerts a pressure over the postrolandic area sufficient to lessen its sensitiveness to afferent impulses; usually, however, merely a hypesthesia results; astereognosis may be present.

F. CONVULSIONS.—Spasmodic twitchings, and even convulsions, usually of the localized Jacksonian type, occur most frequently as the result of cortical irritation from the presence of subarachnoid and subpial (cortical) hemorrhages; occasionally, subdural clots produce them (confirmed by operation). In the other forms of intracranial pressure and hemorrhage convulsions are rare.

G. REFLEXES.—The presence of severe shock is an important factor in influencing the activity of the superficial and deep reflexes. In less severe degrees of shock the skin-reflexes cannot be elicited, while the deep reflexes are present, and in the extreme condition of shock they may both be entirely absent. As the patient recovers from the shock, first the tendon-reflexes return and then the skin-reflexes.

These reflexes usually become more and more active until they are distinctly exaggerated, and if either pyramidal tract is compressed or injured intracranially, then the definite signs of such involvement are to be recognized by the patella and ankle-clonus, the dorsal flexion of the large toe upon plantar stroking (Babinski's sign), and markedly increased tendon-reflexes of the arm and leg of the opposite side of the body, whereas the abdominal skin-reflexes are usually lessened or even abolished on the side opposite to the lesion. It is, however, rare for these signs to be unilateral alone, unless in cases of lesions affecting only one side of the cortex, such as fractures of the skull with a unilateral extradural hemorrhage. In the majority of cases of fracture of the skull, both sides of the brain have been so damaged that there is a marked exaggeration of the reflexes of both sides of the body, and in many cases a bilateral extensor reflex of the toes; this latter sign may last but a few hours in the mild cases, showing that no extensive damage has been done to the pyramidal tract; however, it is a very reliable sign and its presence is always very significant. In cases where one side of the cortex has been damaged more than the other side, the clonus and the Babinski sign will persist on the side of the body opposite the more damaged side of the cortex and gradually fade away upon the side of the body opposite the less damaged cortex.

Increased intracranial pressure due to a simple edema alone is sufficient to produce these signs of pyramidal tract affection, and the signs will persist as long as the edematous condition remains—in the mild cases for several days; in the more severe cases, sometimes for 2 weeks and even much longer. In several cases of fracture of the skull of moderate severity, I have seen exaggerated reflexes and even a bilateral Babinski reflex remain longer than 3 months after the date of the injury, together with a general nervous instability associated with restlessness, irritability, and emotionalism of the extreme type, the patient being easily depressed, with crying spells, and more easily angered.

H. LUMBAR PUNCTURE.—As a definite diagnostic aid in fracture of the skull, the value of lumbar puncture has been very much overestimated; the absence of blood and of pressure does not exclude a fracture of the skull with hemorrhage, either extradural or intradural. In several cases the report of the cerebrospinal fluid obtained by lumbar puncture has been negative, and yet, at operation, intradural bleeding has been found; an explanation of this might be a possible blockage of the intracranial circulation of the cerebrospinal fluid.

Besides, in cases of high intracranial pressure, it is distinctly dangerous to withdraw cerebrospinal fluid by lumbar puncture for fear of the medulla being forced down into the foramen magnum upon lessening the intraspinal pressure. In one of my cases early signs of medullary compression (with recovery) appeared immediately after the withdrawal of only 10 c. c. of cerebrospinal fluid by lumbar puncture, and in a second case, after more than 20 c. c. had been allowed to flow out (by mistake under the impression that it would relieve the patient), such rapid marked signs of medullary compression appeared that I removed the posterior half of the foramen magnum in the hope that the patient might recover, but it was too late; I found the medulla firmly jammed down into the foramen magnum, choking it.

If a lumbar puncture is considered advisable, I now remove not more than 5 c. c., very slowly (drop by drop), and then, after 15 minutes have elapsed, if there are no contra-indications, I allow 5 c. c. more to escape. To obtain only this small amount of cerebrospinal fluid when it is under high pressure is very difficult, at times it being necessary to hold a sterile gloved finger over the end of the puncture needle. Absolute asepsis is naturally important.

In mild degrees of intracranial pressure resulting from a fracture of the skull or in cases of severe concussion, it is conceivable that repeated removals of small amounts (not more than 5 c. c.) of cerebrospinal fluid by lumbar puncture would lessen the headache and other discomforts resulting from increased pressure. However, I should not advise it as a routine procedure, as there is a definite element of danger in its use, even in cases of mild intracranial pressure. In four border-line cases, 5 c. c. of cerebrospinal fluid were removed by lumbar puncture to ascertain the presence or absence of blood; such an immediate relief of the intense headache was experienced by each patient, and in 2 of them such a marked "brightening" mentally and awakening from their stuporous condition, that a lumbar puncture was repeated later in each of these cases and apparently with good results. The recovery was uneventful.

I. X-RAY.—In cases of possible fracture of the skull, an X-ray picture will frequently reveal a "crack" in the squamous portion of the temporal bone or in the greater wings of the sphenoid bone external to the orbit. Both sides of the head should be exposed; a stereoscopic view is sometimes very helpful.

Naturally, the treatment of these cases remains the same, whether there is a fracture or not—a decompression being considered only in the presence of marked intracranial pressure. The operation is not to remedy the fracture, but to offset the results of the fracture and the injury to the brain. In my opinion, all mild cases of head injury should be treated as possible fractures of the skull by the palliative expectant method, and a decompression advised only when this method fails to prevent an increasing intracranial pressure as shown by the ophthalmoscope.

J. URINE EXAMINATION.—An examination of the urine within 6 hours after the injury will frequently reveal the presence of sugar; especially is this true of basal fractures extending through the middle fossa, and particularly into the sella turcica, thus disturbing the pituitary body.

THE SIGNIFICANCE OF INTRACRANIAL PRESSURE

Under normal conditions, the height of intracranial pressure depends upon the general arterial blood pressure in a direct ratio—the higher the blood pressure, the higher the intracranial pressure, and the lower the blood pressure, the lower the intracranial pressure. This ratio remains constant unless marked pathological lesions occur intracranially, such as a large hemorrhage or the terminal stages of a large tumor formation; then the increased intracranial pressure may exceed the arterial blood pressure, temporarily and periodically at first, but if not relieved, then permanently, resulting in the death of the patient. Naturally, the intracranial pressure is highest in the arteries, and then in the capillaries, and lowest in the cortical veins and the large venous sinuses. Other conditions remaining the same, any increase in the amount of inflow of intracranial blood or any blockage of its outflow produces a rise of intracranial pressure.

Another factor, however, in intracranial pressure is the cerebrospinal fluid. Secreted by the choroid plexus of veins in the third ventricle, it passes into the lateral ventricles and also backward into the fourth ventricle, where it escapes through the foramina of Majendie and Luschka into the subarachnoid spaces to bathe, as it were, the cortex of the brain and the surfaces of the spinal cord—floating them to a certain extent.

It is believed that the cerebrospinal fluid reënters the circulation by means of the pacchionian bodies and the numerous cortical veins. Whether this fluid brings nourishment to the nerve cells or carries away waste products is unknown. The amount of cerebrospinal fluid depends upon many factors, especially the rate of its secretion and the rate of its excretion; in hydrocephalus it is unknown whether there is an increased secretion or a lessened excretion. Its amount tends to be increased by a rise in the blood-pressure; especially is this so in traumatic conditions of the skull, particularly fractures of the skull.

One effect of a prolonged increase of intracranial pressure is the resulting partial anemia of the cortex; the amount of blood reaching the cortex is thus lessened, so that the delicate cortical nerve cells do not receive their normal blood supply, and a partial starvation of them results, so that the cortex becomes pale and an increase of neuroglia cells occurs in it. This increase of nerve connective tissue tends to prevent the normal functioning of the cortical nerve cells, and is, in my opinion, the cause of many of the so-called "post-traumatic neuroses" following fractures of the skull, such as persistent headaches, dizzy spells, indefinite pains in the head, changed personality to one of emotional excitement and irritability, or to one of depression, general nervous instability, fainting spells, etc. A high intracranial pressure lasting 7 days or more is apparently sufficient to produce these conditions. One case at autopsy, following fracture of the skull 8 years previously, showed a marked increase of the neuroglial tissue cells in the cortex; since the fracture of the skull with definite signs of an increased intracranial pressure, the patient had suffered from intense headaches and at times epileptiform attacks. There may have been in this case subpial punctate hemorrhages causing an unusual amount of connective-tissue formation in the cortex.

Kocher's First Stage of Compression.—The effects of increased intracranial pressure vary according to whether the compression is sudden and acute, or gradual and chronic; if the latter, then a certain amount of adaptation of the brain occurs, so that a much higher pressure may be endured without producing marked signs of its presence; this occurs very frequently in slowly growing tumor formations of the brain. In either case, whether acute or chronic, the increased intracranial pressure first expels the excess cerebrospinal fluid and, as brain tissue itself is non-compressible, it then compresses the local blood-vessels, so that the amount of intracranial blood is slightly lessened; as the blood in the cerebral veins is under a very low pressure, these veins become filled with blood and dilated so that the next sign is a venous stasis, its symptoms being headache, drowsiness, and possibly stupor; the pulse, respiration, and blood-pressure are not affected. This forms Kocher's first stage of compression clinically—the stage of compensation. The retinal veins are usually much dilated.

Kocher's Second Stage of Compression.—If, however, the intracranial pressure still rises, it tends to approximate the pressure in the capillaries, and so a partial anemia results. If the pressure is a local one, such as that due to a middle meningeal hemorrhage or a depressed fracture of the vault, then a local anemia of the underlying cortex results with impairment of function of that cerebral area; naturally, the more distant the areas of the brain from the localized compression, the less are they affected, and as the falx cerebri and the tentorium form 3 fairly separate compartments of the brain, it is possible for 1 hemisphere to be disabled by an extradural hemorrhage and yet the opposite hemisphere, and especially the cerebellum and medulla situated beneath the tentorium, to be only slightly affected. The tentorium is of the utmost importance in this respect—a protecting barrier for the all-important medulla. If, on the other hand, the increased pressure is of subdural origin, as a subdural hemorrhage or a sudden increase in the amount of cerebrospinal fluid following a fracture of the skull, then the pressure becomes general and all portions of the brain are equally affected; in the case of a subdural clot, naturally the underlying cortex is more compressed than the more distant areas of the brain, although in these cases of general pressure it is the effect upon the medulla that is to be feared; subtentorial local pressure would produce the same impairment as high intracranial general pressure.

The first effect upon the medulla of a continued rise of the intracranial pressure is one of slight anemia of the medulla, producing a slow pulse of 60 or below, due to the stimulation of the vagus nucleus, and a slight rise in the general arterial blood-pressure due to the stimulation of the vasomotor center, causing not only a constriction of the peripheral blood-vessels themselves, but especially of those vessels of the splanchnic field. Besides, the venous stasis becomes more marked, so that the headache is severe, associated with restlessness and even delirium; a definite cyanosis appears. These definite, though moderate, signs of high intracranial pressure form Kocher's second stage of compression clinically. An ophthalmoscopic examination reveals large dilated retinal veins with or without edema of the disks. This period is undoubtedly the best time to operate to relieve the intracranial pressure—before the signs of extreme medullary compression have occurred.

Kocher's Third Stage of Compression.—Kocher's third stage of compression clinically consists of the major or bulbar signs of compression. As the intracranial pressure continues to rise, it produces a greater anemia of the medulla, so that the intracranial pressure at times may equal the capillary pressure of the medulla; if it were not for the regulatory mechanism of the circulation in the medulla, such an occurrence would result in the immediate and permanent cessation of the cardiac and pulmonary activity, and, therefore, the death of the patient. Fortunately, however, as the anemia of the medulla becomes greater, this very absence of blood so stimulates its vasomotor center that the general arterial blood-pressure is raised, more blood is forced into the medulla, and in this manner the partial anemia is overcome, at least temporarily. Clinically the picture is most striking; as the intracranial pressure increases until it tends to prevent the normal flow of blood into the medulla, the resulting partial anemia so stimulates the vagus center that the heart rate gradually becomes lowered to 50 and below, and the pulse to a full bounding character; the respiration becomes less and less frequent until a period of apnea or non-breathing results, due to the anemia of the respiratory center in the medulla; the patient may not breathe for 40 seconds or even more. During the earlier part of this period of "down-wave," the blood-pressure falls slightly, the patient gradually becomes more and more stuporous, the pupils slowly dilate, and the reflexes are abolished —the results of a definite anemia of the medulla. Then, as this prolongation of the medullary anemia stimulates the vasomotor center to renewed activity, the general blood-pressure is gradually raised to overcome the intracranial pressure until blood is forced into the medulla, the heart rate increases, and then the patient begins to breathe again as a result of the respiratory center being resupplied with blood. During this period of "up-wave," the cyanosis is extreme, the pupils contract, and the patient may groan, become restless, and even conscious. The reflexes return and the ophthalmoscopic examination reveals double papilledema or "choked disks," i. e. the intracranial pressure is so high that the resulting venous stasis produces an edema of the optic nerve discs so that their margins and the entire discs themselves are obscured, the retinal veins are dilated and at times buried in the edematous retina. Even the other extracranial veins of the scalp, and particularly of the upper eyelids, are dilated.

As the medulla becomes supplied with blood again following this period of "up-wave," the stimulation of its vasomotor center is lessened, so that gradually the general arterial blood-pressure diminishes until the symptoms and signs of the "down-wave" become more and more marked; then the "up-wave" begins again, as outlined above, and this periodicity of symptoms and signs depending upon the rise and fall of the general blood pressure causing the Cheyne-Stokes type of respiration (Traube-Herring waves) occurs again and again. This condition may continue for hours.

Kocher's Fourth Stage of Compression. Unless the intracranial pressure is now quickly relieved by an operation (and even with an operation the chances for recovery at this stage of compression are slight), this regulatory mechanism of the medulla will finally become fatigued, so that the vasomotor stimulation will no longer be able to raise the general arterial blood-pressure above the intracranial pressure, and during one of the "down-waves" a permanent fall of blood-pressure will occur; respiration will no longer begin again, and the heart will continue to beat irregularly and rapidly as a separate organ until the blood-pressure gradually falls to zero, so that even the heart itself will cease beating. This stage of respiratory paralysis, associated with rapid and irregular cardiac efforts, dilated pupils, profound coma and complete muscular relaxation, and a permanent fall of the general arterial pressure, forms Kocher's fourth stage clinically of a permanent anemia of the medulla—the stage of loss of compensation or the terminal stage, always resulting in the death of the patient.

TREATMENT OF FRACTURES OF THE SKULL

1. MILD CASES

In my opinion, it is not rare that mild cases of fracture of the skull consisting of a simple "crack" or linear fracture, especially in either squamous portion of the vault, are treated as cases of severe concussion—a "bad bump on the head"—and the fracture is not recognized, owing to the triviality of the symptoms and signs. In these cases an X-ray picture is of value, although the treatment remains the same—fracture or no fracture. It is indeed very suggestive of a "crack," if a subconjunctival hemorrhage appears 1 or 2 days after a "bump," and especially if a hematoma develops in the temporal muscle. Such cases should always have an X-ray picture, and it will be surprising how many linear fractures of the sphenoidal wings and of the underlying squamous portion of the temporal bone will be discovered. Four of my cases which had received severe "bumps" on the head, and showed only the symptoms and signs of concussion, had linear fractures of either the squamous bone or the sphenoidal wings, as shown by the X-ray. Repeated ophthalmoscopic examinations were negative.

The treatment of cases of severe concussion should be the same as for the cases of latent linear fracture of the skull (as revealed by the X-ray) or of possible fractures of the skull; that is, the treatment should be directed toward a lessening of a high blood-pressure and, in this way, the lowering and even avoidance of an intracranial pressure; this is particularly true if there is an intracranial hemorrhage of greater or less severity. In all cases of injury to the head, shock is an important factor and should always receive immediate attention. As routine treatment, the following measures are important:

1. **Absolute Rest in Bed, Quiet and Warmth.**—The room should be cool and darkened, and there should be the greatest possible freedom from noise and from disturbing elements. Relatives should be excluded from the sick room unless the patient is unconscious, and even then it is a wise measure; the emotions should not be aroused. Small repeated hypodermic injections of morphia (gr. ⅛) are most useful in insuring quietness to excitable and even delirious cases. The head should not be elevated beyond the height of 1 pillow, and frequently it is advisable not to raise the head at all, and even to lower it in the cases of severe shock, by elevating the foot of the bed. Warm blankets and "not too warm" hot-water bags should be applied to the body in cases of severe shock; then flannel or rubber bandages may be wrapped about the legs, and even the arms. In cases complicated by alcoholism an immediate gastric lavage is beneficial. The patient should remain quietly in bed for at least 2 weeks. All reading should be prohibited; many "nervous breakdowns" following mild fractures of the skull result from the neglect of this simple precaution. The patient should not attempt to return to his business for at least 3 months.

2. **Catharsis.**—An immediate enema of soapsuds or oil should be given, and then a cathartic administered by mouth—either a saline or calomel in ½-gr. doses—followed by a saline purge. Vigorous catharsis is very important, and yet in cases of severe shock it should be delayed until the patient is recovering from the shock. In cases of unconsciousness, only enemata should be used. It is my routine hospital practice to give a soapsuds enema to patients each morning for at least 2 weeks after the injury; I have repeatedly observed the blood-pressure to drop 10 to 15 points following a soapsuds enema with a large movement of the bowels.

3. **Cold Compresses to the Head.**—Unless the shock is severe, a large ice-bag surrounding the entire head should be used. The coldness of the ice tends in a small way to lessen the cerebral circulation and so diminish and even prevent the cerebral edema resulting so frequently from injuries to the head; in

this manner a lowered intracranial pressure is obtained. The ice-bag should not be allowed to remain about the head for periods longer than 1 hour; after an interval of ½ hour, it can be replaced for another period of 1 hour, and so on. Patients will frequently ask for the ice-bag to be replaced—it so relieves the "throbbing" in the head and the headache—and the request should always be granted, as the patient is an excellent judge of its efficiency; the patient will not ask for the reapplication of the ice-bag if there is neither throbbing nor headache to be lessened.

4. **Diet.** A liquid diet should be adhered to for several days. Practically any liquid food may be given, although I prefer to avoid milk and its modifications for at least 3 days after the injury, for fear of the formation of gas and resulting abdominal discomfort. Alcohol in any form whatsoever should be avoided; however, if the patient is alcoholic, it is wise to administer at least ½ ounce of whisky or brandy 3 times a day for fear of a possible onset of delirium tremens.

5. **Drugs.** Except for the use of morphin in conditions of restlessness and shock, I have not found any drugs worth mentioning in the treatment of possible fractures of the skull. Strychnia may be given in cases of shock, but its real value is doubtful. Most important, however, in cases of severe shock is hot black coffee given slowly by rectum in amounts of 4 to 8 ounces; I have frequently seen remarkable improvement in the general condition of the patient after its administration; it is my routine practice to use it now after cranial operations of any great severity.

Indication for Routine Treatment. The routine treatment, as briefly outlined above, should be followed in all cases of severe injury to the skull that is, an effort should be directed toward a lessening of an increased blood pressure and in this manner a lessening of the increased intracranial pressure achieved. Naturally, if the symptoms and signs of shock are the more prominent, then we should direct the treatment toward relieving the condition of shock, and when this has been accomplished, the intracranial condition can be considered.

If the patient is in a condition of shock, he should not be disturbed—not even for the purpose of making an examination. It will not benefit him, and in some severe cases it may do him harm; the treatment remains the same as above whether the patient has a fracture of the skull or not, and for this reason I usually refrain from making a physical examination until a definite general improvement from the shock is apparent.

Use of the Ophthalmoscope.—When this general improvement does occur, it is then of the greatest importance to ascertain the presence or absence of a marked increase in the intracranial pressure as registered upon the fundus of the eye and revealed by an ophthalmoscopic examination. For this purpose an electrical ophthalmoscope is very satisfactory; the battery may be carried in the handle of the instrument or in a separate box.

Proficiency in the use of this instrument is essential to accurate diagnosis. One should practice first with normal eyes so that any abnormal dilatation of the retinal veins and changes of the optic disks may quickly be noted. The proficient use of this "direct" method in the examination of the fundus is not only simpler and easier to acquire than the old "indirect" method of reflected light and an interposed lens, but it is much more accurate in revealing the minute details and changes in the fundus of the eye; with the "indirect" method it is sometimes difficult to distinguish slight pathological changes occurring in the fundus.

In cases of severe concussion with or without fracture of the skull, it is possible for the ophthalmoscope to reveal slight dilatation of the retinal veins —that is, a moderate degree of increased intracranial pressure. In mild cases the intracranial pressure does not proceed beyond this height, which produces merely a dilatation of the retinal vessels, and in many of the cases of simple concussion not even a dilatation of the retinal veins results.

It is in those cases, however, which show not only a dilatation of the retinal veins, but the added blurring and haziness of edematous optic disks, that we should be careful to make repeated ophthalmoscopic examinations of the fundus in order to ascertain the earliest signs of a still increasing intracranial pressure —whether it be due to a simple edema of a "swollen" brain or to a hemorrhage. The signs of a still increasing intracranial pressure, beyond a dilatation of the retinal veins, are, first, an edematous blurring and obscuration of the nasal margin of the optic disk, then a similar haziness of its nasal half, and, finally, the blurring of the temporal half, resulting, in the severe cases, in the total obscuration of the optic disk—"choked disk."

Those cases of cranial injury with intracranial pressure sufficent to produce a dilatation of the retinal veins and a blurring and haziness of the nasal margin of the optic disk can still be treated successfully by the palliative expectant treatment, but if the ophthalmoscope reveals a still greater pressure, sufficient to cause an obscuration of the nasal and temporal halves of the disk, that is, a beginning "choked disk," then it is always advisable and safer to relieve the increased intracranial pressure as soon as possible, whether it is due to cerebral edema or to hemorrhage; the principle remains the same. In these latter cases a decompression is advisable, not only to save the life of the patient by avoiding a medullary edema, but to lessen the severity and number of the posttraumatic conditions so frequently following a prolonged intracranial pressure.

Unless the intracranial pressure is very high, resulting from a large, rapid hemorrhage, it is very unusual for the ophthalmoscope to reveal marked changes in the fundus within 3 hours after the injury; the veins may become full and dilated, but it is rare for an obscuration of the optic disks to occur within this period. If it does, then an immediate decompression is most advisable. In my series of cases it was observed that fractures of the occipital bone beneath the tentorium and around the foramen magnum were usually responsible for this rapid and high increase of the intracranial pressure, due possibly to a blocking of the iter and consequently the ventricles by either a subtentorial hemorrhage or a cerebellar edema; that is, similar to the results of any subtentorial lesion, whether a tumor, an abscess, or a cyst. Frequently the intracranial pressure may become so high that the extracranial vessels in the scalp, and especially of the upper eyelids, become filled and dilated due to the blocking of the venous circulation intracranially. Naturally, the prognosis is very poor in these cases, operation or no operation; an early medullary edema is the outcome, these patients dying within 6 to 10 hours after the injury.

It is, however, in those cases which do not show marked signs of intracranial pressure until after 3 hours or more following the injury that a better prognosis can be given. Repeated ophthalmoscopic examinations are essential—at least once every hour—and if the changes in the fundus advance beyond a fulness of the veins and a blurring of the nasal margins of the optic disks, then an immediate decompression is advisable. Fortunately, however, with the aid of the palliative expectant treatment as outlined above, the intracranial pressure does not increase beyond this degree in almost 50 per cent. of the cases of fracture of the skull, so that an operation is not necessary and the recovery will be uneventful. It may require 4 to 6 days for these signs of moderate intracranial pressure to subside, but apparently this duration of moderate pressure does not produce any harmful effects.

Prolonged total loss of consciousness in fracture of the skull usually indicates a high degree of intracranial pressure associated with more or less shock. Loss of consciousness, however, is not necessarily associated with a high intracranial pressure, nor does a high intracranial pressure always produce a loss of consciousness. Some of the cases in my series having the highest intracranial pressure (sufficient to produce the early signs of a beginning medullary compression) were called only "unusually drowsy" and "stuporous," and were easily aroused by supra-orbital pressure, by pricking the skin, or even by shouting the patient's name.

In cases of slowly progressing hemorrhage and of edema intracranially, as revealed by the ophthalmoscope and confirmed by operation, the various stages of "feeling of tiredness," then drowsiness, stupor, coma, and finally total unconsciousness, may be observed within a period of several hours. It is not a very unusual occurrence to have such patients walk into the hospital with the complaint of "throbbing" in the head and severe headaches following a recent blow or injury to the head, and then pass gradually through these stages to total unconsciousness. The vast majority of patients, however, following a fracture of the skull are more or less comatose, and it is of the greatest importance to observe whether the degree of coma lessens or increases.

Aseptic Measures.—It is of the greatest importance, also, in all lacerated wounds of the scalp to shave carefully the surrounding area—at least 1 inch beyond the margins of the laceration; to cleanse the wound thoroughly with green soap, and even alcohol or a weak solution of iodin (unless the underlying vault is fractured), and then to suture the edges of the wound very loosely, having placed a drain of rubber tissue at each end of the laceration. The danger of infection from foreign bodies, hair, dirt, etc., and a resulting meningitis is so great that the utmost care and strictest asepsis are essential in all wounds of the scalp. Only too frequently are such wounds carelessly treated—the surrounding scalp not being shaved, etc.—and the results are at times appalling.

CASES OF CONCUSSION; NO FRACTURE ASCERTAINED

CASE 1

——, John. 12 years. School.

Diagnosis: Concussion.

Admitted Polyclinic Hospital, December 5, 1913. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. Patient was beaten and kicked by 3 men, 1 hour before admission. Comatose. Vomited blood. Ambulance.

P.E. T. 99. P. 98. R. 26. B.P. 110. Semiconscious. Pale and in shock. Bleeding from nose. Both eyes ecchymosed; right pupil larger than left; react normally. Knee-jerks present; not exaggerated; equal. No Babinski. No abdominal reflexes. Abrasion and hematoma of forehead. Extensive hematoma involving right parietal area of scalp. Fundi: Negative; no dilatation of retinal vessels; no edema present. X-ray—negative.

Treatment: Expectant palliative treatment. Hot black coffee, oz. iv, per rectum upon admission and repeated after 4 hours.

Condition at discharge, December 10, 1913, 5 days after admission: T. 98.4. P. 84. R. 22. Pupils equal and react normally. Right orbital ecchymosis. Reflexes negative. Fundi negative.

June 1, 1914. No complaints.

August 27, 1914. No complaints. P.E. Negative.

CASE 2

——, George. 52 years. Mechanic.

Diagnosis: Concussion, associated with alcoholism. No fracture of skull ascertained. No operation.

Admitted Polyclinic Hospital, January 1, 1914.

F.H. Negative.

P.H. Has been frequently intoxicated.

P.I. Patient is supposed to have fallen from a street car and struck head against curbing. Unconscious. Ambulance.

P.E. T. 96.8. P. 76. R. 20. B.P. 130. Rather obese. Breathing deep and stertorous. In deep coma—alcoholic. Clammy, cold skin. Pupils widely dilated; react sluggishly. Lacerated scalp over right occipital bone; no fracture ascertained. Knee-jerks not elicited. No Babinski. Abdominal reflexes absent. Fundi negative. Urine: Trace of albumin, no casts. Treatment: Expectant palliative. Patient was unconscious for 2 days and could not speak until 2 days later, but no evidences clinically of hemorrhage. Reflexes returned normally 16 hours after admission. Patient gradually improved.

Condition at discharge, January 7, 1914, 6 days after admission: No complaint other than an occasional headache. Physical examination negative. Fundi: negative. Patient has signed the pledge.

June 5, 1914. No complaints. Physical examination negative.

August 24, 1914. No complaints. P.E. Negative.

CASES OF FRACTURE OF THE SKULL; MILD SIGNS OF INTRACRANIAL PRESSURE; NO OPERATION

CASE 1

———, Gus. 54 years. Longshoreman.

Diagnosis: Concussion. Depressed fracture of outer table of skull. No operation.

Admitted Polyclinic Hospital, February 5, 1914.

F.H. Negative.

P.H. Negative.

P.I. While at work, patient was struck by revolving wheel of machine. Unconscious. Ambulance.

P.E. T. 100.4. P. 100. R. 20. B.P. 125. Comatose. Not alcoholic. Two stellate lacerations over right side of head. Upper wound, 2 tiny depressions of about ¼ in. diameter; outer table of vault probably, as ascertained with probe. Right intercostal tenderness; no fracture of ribs ascertained. Pupils equal and react normally. Fundi: Slightly dilated retinal vessels; some haziness of nasal margins. No paralysis. Knee-jerks present and equal. No Babinski. No abdominal reflexes elicited. X-ray of vault negative.

Treatment: Wound probed; scalp sutured loosely. Right side of chest strapped. Expectant palliative treatment with excellent recovery.

Condition at discharge, February 7, 1914, 2 days after admission: T. 98.6. P. 80. R. 20. Scalp infected (?). Reflexes negative. No change in appearance of fundus.

February 10, 1914. Fundi: Some dilatation of retinal veins and slight blurring of nasal margins. Complains of severe pains in back. To return for observation.

March 15, 1914. No complaints. Reflexes negative.

May 28, 1914. Fundi negative. No complaints. Physical examination negative.

September 2, 1914. No complaints. P.E. Negative.

CASE 2

———, Frank. 20 years. Student.

Diagnosis: Fracture of base of skull through right petrous bone. No operation.

Admitted Polyclinic Hospital, September 27, 1913. Referred by Dr. M. Allen Starr.

F.H. Negative.

P.H. Negative. No history of fainting spells.

P.I. During the evening, the patient had been indulging in all sorts of food and non-alcoholic drinks; while riding upon an open Sixth Avenue car, he suddenly felt faint, arose, and then fell headlong to the street. Semi-conscious. Ambulance.

P.E. T. 100. P. 98. R. 28. B.P. 120. Well nourished. Vomiting profusely. Semi-conscious. No bleeding from ears, nose or mouth. Reflexes: All increased, but no inequality. No Babinski. Fundi: Vessels slightly dilated; no blurring of nasal border. Nystagmus (rotary) to both right and left, though right is greater than left. Possibly a slight weakness of right face. Otoscopic examination revealed a hemorrhage into right middle ear, tympanic membrane remaining intact.

Treatment: Expectant palliative treatment. Ice-bag about head. Catharsis. Soap-suds enema daily. Liquid diet. September 28, Dr. John Page punctured right ear drum, allowing clotted blood to escape. Sense of pressure over right side of head relieved; nystagmus disappeared, undoubtedly being vestibular in origin. Uneventful recovery.

Condition at discharge, October 4, 1913, 8 days after admission: No complaints, only slight unsteadiness of both legs—cannot stand upon one leg. Otherwise normal. Fundi negative.

May 15, 1914. No complaints. Physical examination negative. Still some impairment of hearing in right ear.

Case 3

———, Michael. 41 years. Car inspector.

Diagnosis: Concussion. Fracture of the vault, outer table. No operation.

Admitted Polyclinic Hospital, December 31, 1913.

F.H. Negative.

P.H. Negative.

P.I. Patient was trying to stop a runaway street car; was struck by a plank of wood, which knocked the back of his head against the curbing of pavement. Unconscious for 20 minutes. Ambulance.

P.E. T. 101.6. P. 88. R. 20. Heavily built man. Mild shock. Conscious. Lacerated wound over left occipital bone; depressed fracture of outer table apparently. Contusion of forehead. Compound fracture of nose; profuse bleeding. Hematomesis. Colles fracture of left wrist. Fundi negative. Knee-jerks present and equal. No Babinski nor Oppenheim. Abdominal reflexes present and equal.

Treatment: Expectant palliative. Recovery uneventful.

Condition at discharge, January 5, 1914, 5 days after admission: T. 98. P. 80. R. 18. Scalp wound clean. Physical examination negative. Fundi negative.

May 12, 1914. No complaints. Physical examination negative.

August 22, 1914. No complaints. P. E. Negative.

Case 4

———, Harry. 17 years. Elevator boy.

Diagnosis: Fracture of base of skull. No operation.

Admitted Polyclinic Hospital, March 29, 1914.

F.H. Negative.

P.H. Negative.

P.I. While walking in his sleep, patient fell out of window 4 stories high, to back yard; it is believed that a clothes line obstructed his fall. Unconscious. Ambulance.

P.E. T. 99.6. P. 80. R. 24. B.P. 120. Well-developed boy. Semi-conscious. Contusion, hematoma and laceration on right side of head; definite tender point in right temple. Bleeding from both ears and nose. Pupils moderately dilated but equal; normal reaction. Fundi: Dilated retinal vessels; blurring of nasal margin, but not of entire nasal half of disk. Left Colles fracture. No paralyses. Knee-jerks: Left greater than right. Left Babinski. Abdominal reflexes: Right greater than left.

Treatment: Expectant palliative. Frequent examinations of fundi. One day later, patient remembered nothing of past night, but mind was clear on all other points. Reflexes: Left greater than right; no Babinski. Abdominal reflexes: Left depressed. Fundi: Retinal vessels still dilated, but edema of nasal margins is less. Uneventful recovery.

Condition at discharge, April 2, 1914, 4 days after admission: No complaints; no headache. Left reflexes greater than right. Fundi: Retinal veins slightly dilated; no edema. Discharged under observation.

September 2, 1914. No complaint. P. E. Negative.

Remarks: This case illustrates the value of the expectant treatment in mild cases of intracranial pressure, especially when that pressure is due to a simple edema or increase in the amount of intracranial cerebrospinal fluid; especially is this true in persons under 30 years of age. If the definite signs of increased intracranial pressure do not disappear within 48 to 60 hours, then an operative relief of that pressure is advisable. Repeated lumbar punctures to remove small amounts of cerebrospinal fluid may be used in selected cases.

2. DIRECT OR LOCAL FRACTURES OF THE VAULT OF THE SKULL

It should be a routine practice to shave the head in all cases of severe injury of the vault of the skull; many depressed fractures of the vault are overlooked by not taking this simple precaution.

In most of the possible depressed fractures of the vault the overlying scalp is lacerated, so that a probe can be inserted and any fracture of the outer table of the skull can be ascertained. However, it is a fairly frequent occurrence for the outer table to remain intact while the inner table has been fractured inward (Fig. 1).

In all depressed fractures of the vault it is the safe procedure, for fear of later trouble, to make a small trephine opening at the edge of the depressed area, and, by means of a blunt periosteal or dural elevator, to elevate the depressed fragments, if possible, to their original position. If this attempt is not successful, then the depressed area should be rongeured away. Usually the dura remains intact, and I do not believe it should be opened in these cases unless there are clinical signs of a cerebral lesion.

In all cases of direct fracture of the vault, if it is at all questionable whether there is a depression of the fragments or of the inner plate, I consider it advisable to make a small trephine opening at the edge of the possible depression to ascertain its presence or not; if a depression is present, it can be remedied, and if not present, no damage has been done and very little risk has been incurred—other than the usual risk of an anesthetic for several minutes.

The danger of epileptiform attacks occurring after depressed fractures of the vault is much greater than following fractures of the base, undoubtedly due either to small cortical hemorrhages underlying the area of depression and their resulting adhesions or "scar tissue," or to the depression itself, rendering the cortex more "irritable" and hence more liable to "neurone explosure."

In cases having not only a depressed fracture of the vault, but also marked signs of a fracture of the base with intracranial pressure, then an ipsolateral subtemporal decompression should first be performed and then another incision and trephine opening made (as described above) to elevate and even remove the depressed area. By this method the general intracranial pressure is relieved by the decompression and also the harmful local effects of a depressed area of the vault are avoided.

If the depressed area of bone is situated over either the longitudinal sinus or the lateral sinus, then it is frequently wiser not to disturb it, but to rely upon a simple subtemporal decompression to offset any pressure effects of the depressed area.

CASES OF DEPRESSED FRACTURE OF THE VAULT; OPERATION: REMOVAL OF DEPRESSED AREA

CASE 1

——, Fred. 38 years. Plasterer.
Diagnosis: Depressed fracture of vault. Operation: Removal of depressed area.
Admitted Polyclinic Hospital, May 29, 1913. Referred by Dr. C. R. Hancock.
F.H. Negative.
P.H. Negative.
P.I. Four hours ago, patient was struck upon the head by large brick tile. No loss of consciousness, merely stunned. No bleeding from ears or nose. Walked into hospital.
P.E. T. 99. P. 84. R. 24. B.P. 134. Well nourished. Conscious. Lacerated scalp wound 2½ in. in length over left parietal bone extending over longitudinal sinus. Probe revealed a depressed fracture—depression easily palpated apparently 1½ in. in diameter. Fundi: Negative, possibly some slight fulness of veins. Knee-jerks active and equal. Possible tendency to a right Babinski. No paralysis. Lumbar puncture, negative.
Operation: Removal of depressed area, 6 hours after accident. Lacerated wound of scalp enlarged after being carefully swabbed out with tincture of iodin. Depressed area of bone 2 in. long and ½ in. in width exposed. Trephine opening (¾ in. in diameter) made to the left of the depressed fragment (1½ in. to left of longitudinal sinus) and the depressed groove rongeured away over the sinus; no complications. Dura not incised. Catgut for subcutaneous tissues. Silk for skin. Rubber tissue drain. Fair amount of bleeding from scalp.
P.O. 1st day, drain removed and considerable amount of blood serum and clot.
Condition at discharge, June 6, 1913, 7 days postoperative: No complaints. Wound healing perfectly. Reflexes negative; no Babinski. Fundi negative. Returned to work 3 weeks later.
June 5, 1914. No complaints. Physical examination negative.
September 2, 1914. No complaints. P.E. Negative.

CASE 2

——, Charles. 38 years. Steamfitter.
Diagnosis: Old comminuted depressed fracture of vault of skull. Operation: Removal of depressed area of bone.
Admitted Polyclinic Hospital, March 31, 1914. Referred by Dr. R. N. Noble.
F.H. Negative.
P.H. Negative.
P.I. Seven weeks ago, while at work, patient was struck upon the head by a fire-brick falling 8 stories. Momentarily unconscious. No bleeding from ears or nose. Patient walked to a hospital, where he remained 4 days and was discharged; he returned the same day on account of nausea, vomiting and terrific head-

ache. After 7 days, he was again discharged. Since then, he has had continuous headache, especially over eyes; he seems to be in a "cloud" at times. Hearing impaired since the accident.

P.E. T. 99. P. 78. R. 18. B.P. 145. Rather anxious expression. Locally, over left occipital area, was an infected sinus (discharging purulent material) extending down to a depressed fracture of the vault, at least 1 in. in diameter. No paralyses nor areas of anesthesia. Reflexes: Right possibly greater than left. No Babinski. Fundi: Retinal veins dilated; definite blurring of the nasal margins of optic disks; physiological cup shallow. Operation advised to remove the depressed area of bone and the focus of infection for fear of an osteomyelitis of the vault or a meningitis might result.

Operation, April 3, 1914: Removal of depressed area of bone. S-shaped incision through site of old wound which was 2½ in. posterior to left ear and just above left lateral sinus. Pieces of hair and dirt were found buried deep in the depression, probably causing the suppuration. Retractors revealed a comminuted depressed area, the size of a silver quarter. Bony margin rongeured away, and necrosed pieces gently separated until all diseased bone had been removed. Evidences of an old hemorrhage (epidural) were present in the organized tissue lying over the dura and the numerous adhesions, which were removed. Dura not under much tension; evidently thickened, though not opened. Usual closure; 3 drains of rubber tissue. Subcutaneous catgut. Interrupted silk for skin.

P.O. Uneventful.

Condition at discharge, April 15, 1914, 12 days postoperative: No complaints. Says he sees much more clearly. No headaches. Reflexes: Right still possibly greater than left. Fundi: Retinal veins not dilated; nasal margins of disks as before.

June 23, 1914. No complaints. "As well as ever."

August 26, 1914. No complaints.

CASE OF DEPRESSED FRACTURE OF THE VAULT; SYMPTOMS AND SIGNS PERSISTING; RIGHT HOMONYMOUS HEMIANOPSIA. NO OPERATION

———, Clarence. 24 years. Iron-worker.

Diagnosis: Depressed fracture of left occipital bone. Right homonymous hemianopsia. Referred by Dr. W. L. Sneed.

F.H. Negative.

P.H. Three months ago, patient fell a distance of 35 feet from a plank. Unconscious. Ambulance to hospital, where a laceration and depression of the left occipital bone were ascertained and an elevation of the depressed area was attempted. Patient was discharged 3½ weeks later. At the time, patient was very confused mentally and did not remember his hospital residence or his discharge. Since then, severe frontal headaches with dizziness; heaviness of head. Appetite, fair; bowels, constipated. Hematoma over left occipital area, incised one day ago allowing pus to escape.

P.E. July 20, 1914. T. 98.8. P. 82. R. 18. B.P. 128. Lacerated left occipital area still bandaged. Just posterior to left mastoid process is a small sinus discharging a purulent secretion. Reflexes: Right slightly greater than left; no Babinski, but the right toe does not flex, whereas the left one does. Right abdominal reflex depressed. Total right homonymous hemianopsia; otherwise, fields of vision normal (see charts) (Fig. 2). No nystagmus. Ocular movements normal. Right pupil greater than left, which reacts rather sluggishly. Consensual light reaction present. Fundi: Retinal veins dilated; definite blurring of the nasal margins of the optic discs, especially the left; physiological cup shallow. Hearing, normal. Loss of memory, especially for events preceding the accident; at present, very forgetful of names. Brother says he is a "changed boy," very irritable, so much so that they "fear to cross him"; "seems in a trance at times."

Remarks: The right homonymous hemianopsia is undoubtedly due, in this case, to an injury to the left occipital lobe—whether a loss of its cortical tissue or a compression of its cortex due to depressed bone or an extradural or subdural clot; the presence of the consensual light reaction places the lesion behind the optic chiasm.

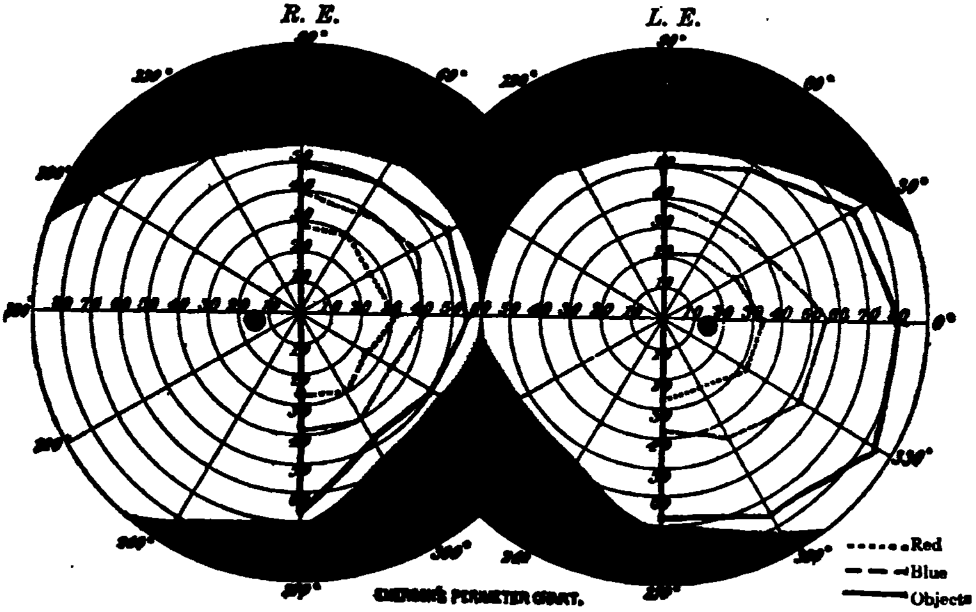

Fig. 2.—Total Right Homonymous Hemianopsia Following a Depressed Fracture of the Left Occipital Bone. The chart shows the right halves of the visual fields blind for objects and also for the colors blue and red. The macula lutea is apparently bisected also; otherwise the visual fields are practically normal.

The fact that the fundi indicate an increase of the intracranial pressure tends to the opinion of compression, and yet it is very common for edematous "swollen" brains following fractures of the skull to produce similar findings in the fundi, and the condition may persist for months. The possibility of abscess must be considered. If the condition of the eyes and mental impairment persists after the local infection has been removed, I shall advise an operation to expose the left occipital lobe.

Cases of Fracture of Base of Skull Associated with Depressed Fracture of Vault; Operation

Case 1

———, August. 39 years. Carpenter.

Diagnosis: Compound depressed fracture of vault; fracture of base. Subdural hemorrhage. Operation: Left subtemporal decompression; elevation of depressed area.

Admitted Polyclinic Hospital, April 21, 1913. Referred by Dr. J. A. Bodine.

F.H. Negative.

P.H. Always well and strong.

P.I. Large iron door fell upon top of patient's head. Unconscious for several minutes, but semi-conscious when brought to hospital. Ambulance.

P.E. T. 99.4. P. 65. R. 18. B.P. 160. Strong, muscular man. Semi-conscious; will reply to questions drowsily and irrelevantly in German. Left pupil larger than right. No paralysis. Knee-jerks present and active, right greater than left. Right Babinski. Right abdominal reflexes depressed. Fundi: Fulness of retinal veins; definite haziness and edema of the nasal halves of disks. Ecchymosis of left eye, subconjunctival hemorrhage. Bleeding from left ear; cerebrospinal fluid observed. Locally, definite depression of anterior portion of left parietal bone. Lumbar puncture: At first blood-tinged, then clear, under some pressure. (This observation is interesting as there was a definite subdural hemorrhage ascertained upon incising the dura.)

Operation, 8 hours after accident, April 21, 1913: Elevation of depressed fragments. Left subtemporal decompression. Large curvilinear incision over left side of head down to left ear margin. Trephine opening made at posterior margin of depression at upper portion of left parietal bone and the posterior portion of the left frontal bone. Opening enlarged with rongeurs and De Vilbiss forceps for removing the depressed margin of the lower fragment of the parietal bone. Effort made to raise depressed area only partially successful. Feared to use too much force, as line of fracture ran across the longitudinal sinus. Small fragment, ½ in. in diameter, removed, exposing dura under high tension. Usual subtemporal decompression made to relieve the intradural pressure. Upon incising dura, much blood-tinged cerebrospinal fluid escaped; also some clots, especially from base. Cortex apparently normal; some congestion and an occasional punctate hemorrhage. Usual closure with rubber tissue drain at lower angle of incision.

P.O. No complications. Second day, clear cerebrospinal fluid draining. May 1st, out of bed.

Condition at discharge, May 6, 1913, 15 days postoperative: No complaints. Wound healed perfectly; decompression opening slightly tense; definite pulsation. Reflexes: Right slightly exaggerated; no Babinski. Fundi negative, except that physiological cup of disk is rather shallow from edematous new tissue formation. Since then, no complaints. Returned to work 1 month after operation.

June 2, 1914. No complaints. Physical examination negative.

August 16, 1914. No complaints. At work daily.

CASE 2

———, Constantino. 53 years. Laborer.

Diagnosis: Fracture of base; depressed fracture of vault. Large extradural hemorrhage and rupture of longitudinal sinus. Operation: Elevation of depression. Right subtemporal decompression.

Admitted Polyclinic Hospital, April 23, 1913. Referred by Dr. J. A. Bodine.

F.H. Negative.

P.H. Negative.

P.I. One hour ago, patient fell 3 stories down upon the first floor, striking right side and top of head. Unconscious. Ambulance.

P.E. T. 99.4. P. 84. R. 20. B.P. 155. Perfectly conscious—Italian of good musculature. Walking about—wanting to go home. Pupils: Right greater than left. No paralysis. No bleeding from ears or nose. Knee-jerks: Left greater than right; possible suggestion of left Babinski. Left abdominal reflexes possibly depressed. Fundi: Definite fulness of retinal veins; right greater than left; slight haziness of nasal halves of disks. Locally, depression of right parietal bone near longitudinal sinus. Lumbar puncture shows numerous red blood cells in cerebrospinal fluid under tension.

Operation, 4 hours after admission: Elevation of depressed fracture of vault; removal of extradural clot. Right subtemporal decompression. Trephine opening made posterior to depressed fracture of right parietal bone; a large dark clot began to exude through opening under great pressure. This prevented by a cotton pad, and a right subtemporal decompression hurriedly made. The extradural clot had extended down to the upper border of the squamous suture. Dura, under fair tension, incised and drain inserted under temporosphenoidal lobe; cerebrospinal fluid blood-tinged. Attempt made to elevate the depressed area of bone, but as the depression extended beyond the longitudinal sinus where the hemorrhage was profuse, it was thought wiser to pack the torn sinus with gauze strips; also a bleeding point on the dura anteriorly. Usual closure, 2 gauze packing strips left in place. No complications.

P.O. April 25th, first dressing. Both gauze strips removed. No hemorrhage. May 3rd, out of bed.

Condition at discharge, May 7, 1913, 14 days postoperative: No complaints. Operation wound healed; some fulness of the decompression opening; pulsates normally. Reflexes negative. Fundi negative. Since then, no complaints. At work, 6 weeks after operation.

May 15, 1914. No complaints. Physical examination negative.

September 2, 1914. No complaints. Works daily.

Case 3

———, Luigi. 28 years. Laborer.

Diagnosis: Fracture of base; compound depressed fracture of right occipital bone; subdural hemorrhage. Operation: Right subtemporal decompression.

Admitted Polyclinic Hospital, June 30, 1913. Referred by Dr. Alexander Lyle.

F.H. Negative.

P.H. Always well and strong.

P.I. Three hours ago, patient was struck upon head by a brick falling 4 stories from a wheelbarrow. Brought to hospital in truck. Unconscious for several minutes.

P.E. T. 100. P. 66. R. 20 (slightly irregular). B.P. 145. Comatose. Bleeding from right ear. Lacerated scalp wound over right occipital lobe, exposing depressed crack in bone. Fundi: Fulness of retinal veins; hazy edema of nasal halves of disks. Reflexes increased, especially on left. Tendency to a Babinski on left. Abdominal reflexes present and equal. Some contusion of hip.

Operation, June 30th, 7 hours after admission: Right subtemporal decompression. Usual incision and removal of bone; no complications. Bone very thick and hard. Dura under high tension and cerebrospinal fluid (blood-tinged) spurted to height of 7 in. Pia arachnoid continued to "sweat" throughout the operation. Usual closure with drain. Injury over right occipital bone examined, revealing a slightly depressed fracture. Swabbed with iodin solution and 2 sutures inserted loosely with three drains.

P.O. No complications. Complains of occasional pains in head.

Condition at discharge, July 21, 1913, 21 days postoperative: No complaints. Physical examination negative. Fundi negative.

April 6, 1914. No complaints. Physical examination negative.

CASE 4

——, Annie. 40 years. Housewife.

Diagnosis: Depressed fracture of vault of skull; rupture of the longitudinal sinus. Operation: 1st, depressed area of bone removed; 2nd, left subtemporal decompression.

Admitted Polyclinic Hospital, April 9, 1914.

F.H. Negative.

P.H. Negative.

P.I. Patient slipped and fell down a flight of stairs. Conscious. Ambulance.

P.E. T. 98.6. P. 90. R. 20. B.P. 140. Conscious—clear mentally. Alcoholic, but not intoxicated. Laceration of scalp—all matted with hair—about 3 in. long, parallel and ½ in. to the left of the superior longitudinal sinus, just posterior to the frontal hair-line. The underlying bony vault was broken and depressed, and brain tissue and dark clots of blood welled into the wound. Depression of left margin at least ½ in. Reflexes active, right possibly greater than left. Fundi negative. No Babinski. Patient said she was all right and wanted to go home. One hour later in the ward, she complained of being dizzy and of a vague headache; becoming drowsy and stuporous.

1st operation, 1½ hours after admission: Laceration of scalp enlarged by curved incision downward at each end, thus making a sort of curvilinear flap incision. Definite fracture 3 to 4 in. in length parallel and ½ in. to left of superior longitudinal sinus; through the fracture, dark blood clots and brain tissue oozed. Trephine opening made external to line of fracture and surrounding bone rongeured away, exposing a large extradural clot, the size of a lemon; through the underlying torn dura, subdural clots extended. Profuse bleeding, due undoubtedly to tear in longitudinal sinus, which was packed with narrow gauze tape. Usual closure: 3 drains of rubber tissue. Owing to the high intracranial pressure forcing brain tissue out into opening, a left subtemporal decompression was immediately performed.

2nd operation: Left subtemporal decompression. Usual incision and removal of bone; no fracture observed. Dura was very tense and upon incising it, almost pure blood in the cerebrospinal fluid spurted 8 in. for 18 seconds; several subdural clots, the size of silver dimes, removed. Cortex congested, otherwise normal. Usual closure with drains.

P.O. Uneventful.

Condition at discharge, April 20, 1914, 10 days postoperative: No complaints. Normal mentality. Reflexes active but equal. No Babinski. Fundi normal. Both wounds healed; decompression area moderately tense.

June 28, 1914. No complaints. Physical examination negative.

September 2, 1914. No complaints. P.E. Negative.

Remarks: It is indeed surprising that a person with such a severe cranial condition could walk about in the hospital with no complaints; and yet it is to be remembered that a sort of natural decompression had been performed by the injury itself, so that through the depressed area of the vault the blood clots and even brain tissue could escape, thus relieving the intracranial pressure. In all probability, however, the patient soon would have gone into a condition of coma due to the continued hemorrhage, cerebral edema and the resulting rising intracranial pressure, and then the prognosis would have been very grave indeed. The subtemporal decompression should have been performed first to lessen the intracranial pressure and thereby the danger of injury to the cortex.

CASES OF OLD DEPRESSED FRACTURES OF VAULT; PARALYSIS AND EPILEPSY; OPERATION DECOMPRESSION; IMPROVED

CASE 1

———, Margaret. 22 years. Servant.

Diagnosis: Old depressed fracture of skull. Epilepsy; right spastic hemiplegia. Left subtemporal decompression.

Admitted Polyclinic Hospital, December 1, 1913. Referred by Dr. L. B. Rogers.

F.H. Negative.

P.H. *Six years ago,* a stone tile weighing 25 lbs. fell upon her head. Taken to Bellevue Hospital, unconscious. Paralysis of right side and impairment of speech. Operation to elevate depressed area of bone. Two months later, paralysis and speech defect improved. *Three years ago,* right-sided Jacksonian convulsions—1 each night; no loss of consciousness. Taken to Bellevue Hospital; operation—bone over depressed area removed. Slight paralysis of right arm and right leg. Speech improved. Now complains of headaches, impairment of vision, drowsiness, and right-sided convulsions, with loss of consciousness.

P.E. Depressed area of bone (new bone) over left upper parietal area over Broca's tract, size of 2½ in. in diameter. Spastic paralysis (slight) of right arm and right leg. Reflexes much exaggerated on right side. Babinski on right. Abdominals apparently equal. Fundi: Veins dilated and retina suffused; mild secondary optic atrophy of disks; margins blurred. Mentality fair. Speech negative. A left subtemporal decompression advised to improve vision possibly, relieve headaches, and, if possible, affect epilepsy.

Operation, December 2, 1913: Right subtemporal decompression. Usual incision and bone removed. Rather vascular bone and exceedingly thick. No complications. Dura quite tense and cerebrospinal fluid spurted ½ in. upon incising it. Typical pia-arachnoid "sweating." Dura very vascular and considerable oozing resulted from it. Drain inserted. Usual closure.

P.O. Negative.

Condition at discharge, December 10, 1913, 8 days postoperative: No complaints. Fundi: Vessels not dilated, but the haziness of new-formed tissue still persists, with the mild secondary optic atrophy.

March 10, 1914. Complains of fulness in head when stooping. No convulsions.

June 4, 1914. Still complains of fulness in head when stooping. No convulsions. Vision has improved slightly. October 10, 1914. No convulsions.

Remarks: This case illustrates the advisability of always removing the depressed area of the vault, if possible, and if the intradural pressure is high, then performing a decompression. Once epileptiform seizures begin, the "habit" may continue—operation or no operation.

CASE 2

———, Albert. 12 years. School.

Diagnosis: Right spastic hemiplegia following depressed fracture of vault. Left subtemporal decompression.

Admitted Polyclinic Hospital, October 26, 1913. Referred by Dr. B. P. Farrell.

F.H. Negative.

P.H. Normal birth at 9 months. *Five years ago,* patient fell from a window (second story). Unconscious in hospital for 5 days. Operation to elevate depressed fracture of the skull; in hospital 6 weeks. Unable to speak for 2 weeks after accident. Since then, spastic paralysis of entire right side.

P.I. Slight improvement during first year after accident; no improvement for past 4 years. In gymnasium of New York Orthopædic Hospital for 2 years. No headache or other complaints. No convulsions.

P.E. Typical right spastic hemiplegia. Over the left parietal area, depressed section of bone—some of which evidently had been removed at the previous operation. Reflexes much exaggerated on right side. Babinski right. No patella nor ankle-clonus. Fundi: Definite signs of old pressure; veins still dilated and walls thickened; mild secondary optic atrophy.

Operation, October 27, 1913: Left subtemporal decompression. Usual incision, extended upward over depressed area of bone. Usual decompression area of bone removed and then the part depressed above the parietal crest removed only partially—owing to absence of dura beneath and the danger of doing more harm than good to the cortex. The dura over decompression area incised as usual—fair amount of tension and cortex bulged to fill the opening. Usual closure with drain.

P.O. Negative.

Condition at discharge, November 8, 1913, 11 days postoperative: No change visible.

May 12, 1914. Spastic paralysis, less marked. Brighter mentally.

Remarks: An earlier relief of the intracranial pressure would have improved this condition very much, unless the cortex itself had been primarily destroyed.

CASE 3

———, Francis. 26 months.

Diagnosis: Old depressed fracture of vault. Paralysis and epilepsy. **Operation:** Removal of depressed area.

Admitted Polyclinic Hospital, April 15, 1914. Referred by Dr. R. A. Hibbs.

F.H. Negative.

P.H. Nine months baby at birth, weighing 9 pounds; third child. Instrumental delivery. Immediately after delivery, a large depression over the left parietal area was observed. At that time, definite paralysis of the right foot and right arm was noticed. Hematoma over right side neck—persisted for 8 months. Several convulsions. Depressed area always remained the same.

P.I. Patient began to walk 4 months ago; dragged right foot and it has become gradually stiff. Definite spastic paralysis of right arm—flexed in its typical position. Mentally bright.

P.E. Fairly well developed. Definite depression over left parietal region, about 3 inches by 1 inch. Pupils equal and react normally. Fundi: Dilated retinal veins; definite blurring of the nasal margins of disks, which are pale. Spastic paralysis of right arm and leg. Drags right foot when he walks. Reflexes: Knee-jerks, right increased; right Babinski present. Spinal curvature—compensatory scoliosis (right dorsal lumbar) present.

Operation, April 16, 1914: Removal of depressed area. Usual decompression incision, only higher. Depressed fracture plainly seen and entire depressed area removed; bone very vascular. Dura very adherent, tense and thickened. Dura opened, revealing an edematous cortex which "sweated" profusely and bulged considerably.

Much hemorrhage from a sinus in the dura; controlled by pack. Usual closure; no complications.

P.O. Convalescence uneventful. Spasticity of right arm and leg much less.

Condition at discharge, April 26, 1914, 11 days after operation: Child can now walk with scarcely any sign of impairment of the right leg, which is no longer "dragged." Child is now using its right hand. Reflexes are still increased on the right side; the Babinski, however, is less marked.

May 6, 1914, 21 days after operation. No complaints. Child can now walk with no limp at all. Right hand is now held down at its side extended. Knee-jerks: Right still more active. No Babinski on the right foot.

June 9, 1914. Complete recovery of the right arm and right leg; no spasticity, though the right tendon-reflexes are still slightly increased; no Babinski. Practically, a normal child.

August 29, 1914. No complaints. P.E. Negative.

Remarks: This case is similar to those cases of spastic paralysis in children due to an intracranial hemorrhage at birth, usually following a difficult prolonged labor with or without instruments; in these cases, the local pressure of the blood clot cannot be seen, as is possible when the bone is depressed, as in the case described here, but the result is the same—a spastic paralysis. A careful ophthalmoscopic examination of the fundus will reveal signs of increased intracranial pressure in those cases due to a hemorrhage, and those are the cases that can be very much improved by a decompression operation; it is not necessary to remove the hemorrhagic clot or its "organized" cystic formation, but merely to offset the effects of its pressure upon the cortex by a relief of the general intracranial pressure.

CASE 4

———, Arthur. 37 years. Miner.

Diagnosis: Old depressed fracture of the vault. Persistent headache; fainting spells. Mild secondary optic atrophy. Operation: Right subtemporal decompression. Removal of depressed area.

Admitted Polyclinic Hospital, April 13, 1914. Referred by Dr. Van Wert, Patton, Pa.

F.H. Negative.

P.H. Negative.

P.I. *Four years ago,* patient was struck over the right forehead by a wooden plank in a mine explosion. Loss of consciousness for several minutes. Laceration of the scalp of the forehead. Remained home in bed for 17 days, but as soon as he got out of bed, patient had pain over forehead and over occipital region. Went to work 4 months later, but was unable to remain longer than 1 day, because of dizziness and severe headache. Ever since then, he has been working a few days and then remains home for 1 week to 1 month, on account of the severe headache and depression. *Three years ago* (one year after injury was received), patient was operated upon and the anterior wall of the right frontal sinus was removed; he remained improved for only 6 weeks and then gradually became as bad as ever; headaches, dizziness, and a marked mental depression. During the past 3 years, patient has worked but a few days, having remained at home for weeks at a time. He now complains of severe pain over eyes (more on right than on left), and in the occipital region. Sleeps very poorly. Vision blurred at times. No nausea or vomiting. Memory not impaired. Definite melancholia.

P.E. T. 98.8. P. 62. R. 20. B.P. 160. Fairly well-developed man. Depressed area of bone 2 in. in width and 1 in. in height over right forehead, just above the right eyebrow. Marked local tenderness, possibly due to pressure upon the right supraorbital nerve. Pupils equal and react normally. Fundi: Dilated veins with definite blurring of the margins of the nasal halves of the disks; physiological cup shallow with new tissue formation; disks rather pale; a mild secondary optic atrophy. Knee-jerks present and equal. No Babinski. Abdominal reflexes: Left possibly depressed.

Operation, April 21, 1914: (1) Right subtemporal decompression. Usual incision; scalp very vascular. Bone was very thick and hard with several large sinuses in it. Dura thickened and under marked tension; whitened and scarred with many adhesions. Cortex revealed old evidences of a subdural hemorrhage—"smoky" pia-arachnoid in sulci with many newly formed blood vessels; many adhesions to dura. Cortex bulged considerably through decompression opening. Pia-arachnoid "sweated" profusely. Usual closure; no complications.

(2) Removal of depressed area of right frontal bone. A curved incision was now made over the depressed area of the right forehead and its concavity exposed. Line of fracture revealed extending from depressed area to the left, beyond the longitudinal sinus, where it bifurcated; the fracture was ¼ in. open and had a splinter of wood 1½ in. long in it. Depressed fracture over frontal sinus removed. Usual closure; no complications.

P.O. Drains removed on second day; no complications.

Condition at discharge, May 3, 1914, 12 days after operation: No complaints. Feels well. Decompression opening still tense; normal pulsation. Reflexes negative; left abdominal not so active as right abdominal reflex. Fundi: the retinal veins are now less filled and less dilated; no edema present.

June 1, 1914. In excellent health. No headaches nor dizziness; no complaints.

September 2, 1914. No complaints.

Remarks: This case had been diagnosed as a posttraumatic neurosis and as hysteria. A careful ophthalmoscopic examination would have prevented this error in diagnosis, and merely illustrates again that no case should ever be considered functional until all organic possibilities have been rigidly excluded.

CASE 5

———, Joseph. 14 years. School.

Diagnosis: Old depressed fracture of the skull. Epilepsy. Operation: (1) Left subtemporal decompression; (2) Removal of depressed area.

Admitted Polyclinic Hospital, March 1, 1914. Referred by Dr. M. Allen Starr.

F.H. Negative.

P.H. Negative.

P.I. Seven years ago, patient was kicked by a horse over the posterior portion of the left frontal region. No loss of consciousness. Ambulance; taken to a hospital and a "bone pressing on the brain" was removed. Patient remained in hospital 3 months. Immediately after discharge from the hospital, patient noticed he had less control of right leg than of left, and his "mind seemed to be in a cloud." Two years ago, first convulsion occurred; general one with foaming at mouth. Four weeks later, patient had second convulsion; general and not Jacksonian in type. Since then, headaches constantly and vomiting spells. Patient has become very refractory, so that it has become necessary to put him in an institution; sudden fits of anger and wanton cruelty have made him dangerous to other children; apparently, the patient's personality has entirely changed. Almost daily convulsions associated with persistent headaches.

P.E. Well-nourished boy. No paralyses. Reflexes: Right greater than left; no Babinski; abdominals present and equal. Fundi: Mild secondary optic atrophy; retinal veins dilated. Locally, depressed area 1½ in. in diameter over left frontal area posteriorly.

1st operation, April 2, 1914: Left subtemporal decompression. Usual incision and bone removed; no complications. Dura thickened and under moderate tension. Upon incising it, cortex rather edematous with thickened pia-arachnoid; signs of pia-arachnoid hemorrhage in sulci and in adhesions between pia-arachnoid and dura. Usual closure with drains.

2nd operation. Curvilinear incision over depressed area. Trephine opening at edge of depression and depressed spongy bone removed. Dura incised, revealing edematous cystic formation, at least ½ in. in thickness; cyst punctured, allowing straw-colored fluid to escape. Drain. Usual closure.

P.O. Negative. No convulsions. Disposition seems to be improving—less quarrelsome. Sleeps well.

Condition at discharge, April 10, 1914, 8 days postoperative: No complaints. No headache. Patient says he feels "brighter and less cloudy." No signs of fits of anger or temper. No convulsions. Wound healed. Reflexes: Right still greater than left, though less so than before operation. Fundi same as at preceding examination, but the retinal veins are not dilated now.

June 12, 1914. No complaints. No convulsions. From reports of his teachers, he is a "changed boy"—not so unruly; has better control of his temper. Is more attentive to his studies. Reflexes: Right equal left. No Babinski. Fundi: Retinal veins not dilated; still signs of mild secondary optic atrophy.

August 26, 1914. No complaints. "A better boy in every way."

Remarks: It will be interesting to follow this case for a period of years. Considering the condition of the cortex as ascertained at the operation, it seems incredible that the boy can remain improved permanently: yet in adolescents, it appears that the cortex can return to a stable and less irritable condition of normality than in adults—even though the epilepsy has persisted over a number of years.

CASE OF OLD FRACTURE OF VAULT WITH DEPRESSION; MELANCHOLIA; REMOVAL OF DEPRESSED AREA; IMPROVEMENT

———, John. 50 years. Fireman.

Diagnosis: Old depressed fracture of skull. Removal of depressed area and puncture of old hemorrhagic cyst. Improvement.

Admitted Polyclinic Hospital, May 20, 1913. Referred by Dr. George E. Brewer.

F.H. Negative. No insanity nor nervous instability.

P.H. Fifteen years ago, while working as marine engineer on a fireboat of the New York Fire Department, patient bumped head violently against door of hold, striking top of head. "Everything became very dark" but does not think he lost consciousness. No bleeding from ears or nose. Complained of severe headache and vomited occasionally during the following 2 weeks; became unbalanced mentally, roamed about in a semi-conscious condition and was finally sent to a general hospital and then transferred to Bloomingdale Insane Asylum, remaining there 11 months. Diagnosis, "melancholia." Patient says: "I was not bug-house enough to be in an asylum, and yet not well enough to be at work." Escaped from asylum and found work; changed positions frequently. Since then confined in Central Islip Insane Asylum, diagnosis being melancholia, and then in several asylums in the West until one year ago—escaping again.

Seven months ago, a trephine opening was made over middle of frontal bone; no improvement followed. Always complained of severe headache over top of head continuously—a dull boring pain. No dizziness. No loss of consciousness. Occasionally some unsteadiness in standing, especially the left leg. Very depressed mentally.

P.E. Well-nourished man. Trephine opening—1½ in. in diameter—over middle of frontal bone. Top of head rather flattened possibly. Reflexes negative. No Babinski but left plantar reflex less marked than right. Some impairment of sense of position of toes of both feet, especially the left. Fundi: Some fulness of retinal veins; no definite edema; signs of mild secondary optic atrophy. X-ray of vault negative; possibly a flattening of top of vault.

Operation, May 21, 1913: Removal of vertex of skull; depressed area removed. Curvilinear incision of scalp. A trephine opening made on each side of sinus and enlarged by rongeurs. Dura over sinus carefully separated from bone and finally the overlying bone rongeured away. No complications as dura and sinus not closely adherent to the bone. Both parietal bones at the coronal suture thickened to ¾ in. and depressed ¼ in. Definite enlargement of dura about sinus at the anterior portion beneath coronal suture. To the right of sinus was a small pulsating cyst the size of an olive and containing a straw-colored fluid. Owing to its thin wall between sinus and cyst, it was punctured but not removed, as its pressure effects would be relieved by removal of the bone. Usual closure.

P.O. No complications. Small drains removed on first day. All sutures removed on the fifth day.

Condition at discharge, May 27, 1913, 7 days after operation: No complaints. Sense of position has returned to toes. Retinal vessels negative. August 1, 1913. No complaints. No longer depressed, and is now working. Apparently normal mentally.

December 2, 1913. Reflexes negative. No impairment of sense of position of toes. Fundi: Vessels negative. Mild secondary optic atrophy as before.

June 5, 1914. No complaints. Working as a watchman for railroad crossing.

September 3, 1914. No complaints. At work daily.

III. SEVERE CASES

Under this heading may be included, on the one hand, those cases of fracture of the skull showing few evidences externally and clinically of fracture, and yet having a high degree of intracranial pressure as revealed by the ophthalmoscope, and, on the other hand, those cases showing severe external evidences of fracture and also high intracranial pressure. It is the high intracranial pressure resulting from the injury to the brain and not the extent and severity of the fracture itself that demands immediate relief impossible of achievement by the expectant palliative method. In aiding to prevent a high intracranial pressure following a fracture of the skull, the expectant palliative treatment is most useful and should always be employed first; but if the intracranial pressure continues to increase during its use, or if the pressure is already high before it is possible to use the expectant palliative method, then it is not wise to delay operative procedure until the patient has reached the dangerous condition of medullary embarrassment, in which death is most liable to occur—operation or no operation; even if medullary embarrassment should not occur, there is the great danger of damage to the delicate cortical nerve cells by a high intracranial pressure of a duration of 10 days and more, and its resulting post-traumatic conditions so common after fracture of the skull associated with a high intracranial pressure.

Fortunately, in some cases, the vault of the skull has been so badly fractured into several movable fragments, that a decompression is not necessary—a sort of natural decompression having been formed; in this manner the intracranial pressure has been so relieved that the patient recovers to the surprise of all. An ophthalmoscopic examination in these cases would show the fundus to be negative. This explanation undoubtedly accounts for the recovery of those cases reported as having the most severe forms of comminuted fracture of the skull and yet a surprisingly uneventful recovery. In other cases, however, the external evidence and clinical signs at first indicate only the mild type of fracture of the skull, and yet the condition of the patient gradually becomes worse, unconsciousness supervenes, and the patient dies with the signs of medullary collapse, usually on the fifth or sixth day after the accident, or, in some cases, as late as the fourteenth day. I am confident that if repeated ophthalmoscopic examinations of the fundus were made in these cases, the increasing intracranial pressure (apparently "latent" clinically) would be ascertained and its immediate relief by a decompression would save the patient. Even if the condition of the patient is carefully followed by repeated ophthalmoscopic examinations, a definite prognosis regarding recovery must be very guarded and naturally should not be given; shock, individual resistance, and possible complications are such important factors in each case that any definite prognosis is most hazardous.

Besides the great danger of medullary compression and, if this danger should be avoided, the possibility of posttraumatic conditions appearing and making the after-life of the patient most pitiful, there is still the always present danger of pneumonia occurring in patients confined to their beds in a semi-conscious condition; especially is this true of patients over fifty, and if alcoholic to any degree. The danger of pneumonia following an anesthetic, if properly administered, is small in comparison. The usual hospital residence following a decompression for fracture of the skull does not exceed 3 weeks, and the patient is usually sitting out of bed on the seventh day postoperative. Besides, delirium tremens is less liable to occur in patients not permitted to remain comatose for a number of days—irrational and poorly nourished.

CASES OF SEVERE FRACTURE OF SKULL WITH SUBDURAL AND INTRACEREBRAL HEMORRHAGE

A. UNILATERAL DECOMPRESSION

CASE 1

———, Robert. 16 years. School.

Diagnosis: Fracture of base and of vault of skull; extradural and subdural hemorrhage. Operation: Left subtemporal decompression.

Admitted Polyclinic Hospital, July 26, 1913. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. Patient was knocked down by wagon at 11 A. M. Unconscious. Bled from nose. Gradually regained consciousness. No convulsions. Complained of severe headache and dizziness. Ambulance.

P.E. T. 100.4. P. 78. R. 20. B.P. 130. Semi-conscious. No paralyses nor anesthesias. Reflexes negative. No Babinski. Abdominals present and equal. Fundi:

Slight dilatation of retinal veins; otherwise negative. Under observation. *One day later,* began having attacks of delirium requiring 2 men to hold him. Fundi: Fulness of veins; no edema of disks. Reflexes: Right greater than left. Tendency to a right Babinski. *Two days later,* continued delirium. Distinctly tender area over left temporo-occipital area. Fundi: Veins filled with a blurring of nasal halves of disks. Reflexes: Right greater than left; right Babinski. Right abdominal reflex absent. Operation now advised.

Operation, July 28, 1913, 2 days after admission: Left subtemporal decompression. Usual vertical incision over left temporal muscle. Upon enlarging bony opening with rongeurs, an extradural clot was exposed, extending backward to a fracture over posterior portion of left squamous bone. Dura under great pressure and upon incising it, a large subdural clot (the size of an English walnut) was exposed in the cortex itself and being extruded by the cerebral tension. The extradural clot extended backward to the fracture of the vault and upon depressing the underlying cortex with the spatula, much free blood escaped, apparently from a torn left lateral sinus. Three drains of rubber tissue were inserted; usual closure.

P.O. No complications. Several mild delirious spells after operation.

Condition at discharge, August 12, 1913, 14 days after operation: No complaints. Reflexes: Right slightly increased; no Babinski. Fundi negative. October 12, 1913. No complaints. Physical examination negative. Has returned to school.

June 7, 1914. No complaints. Working. Physical examination negative.

August 22, 1914. No complaints.

Remarks: The repeated examinations of the fundi in this case afforded an accurate means of observing the gradual increase of the intracranial pressure in spite of the palliative expectant treatment, and in this manner an operation was advised before the patient reached the dangerous period of medullary compression; in my opinion, the usual signs of intracranial pressure, such as a slowed pulse, irregular respiration, high blood pressure, etc., are but crude and very unreliable signs of approaching medullary compression and collapse.

Case 2

———, Frederick. 61 years. Street cleaner.

Diagnosis: Fracture of base. Subdural hemorrhage. Operation: Left subtemporal decompression.

Admitted Polyclinic Hospital, March 13, 1913. Referred by Dr. J. A. Bodine.

F.H. Negative.

P.H. Always well and strong.

P.I. Two hours ago, while working on the street, patient was struck by a taxicab which had collided with a trolley car. Unconscious. Bleeding from left ear and nose; hematoma about left eye. Ambulance.

P.E. T. 98. P. 70. R. 20. B.P. 175. Rather emaciated old man. Could be roused by supra-orbital pressure. Very irritable. No definite paralyses. Epileptiform (Jacksonian) twitchings of right arm. Pulse irregular. Right pupils greater than left. Knee-jerks: Right greater than left. Right Babinski. Fundi: Veins rather full and nasal halves of disks hazy and edematous. Possible left lower facial weakness. Internal strabismus—*"congenital."* Lumbar puncture showed blood-tinged cerebrospinal fluid under fair tension.

Operation, March 13, 1913, 2 hours after admission: Left subtemporal decompression Usual incision. Dura was very tense. Upon incising it, very bloody cerebrospinal fluid welled up from the base through opening, as if a basal sinus had been injured. Drain inserted under temporosphenoidal lobe and incision hastily closed.

P.O. Drain removed second day. Mentally normal. No complications other than a chronic bronchitis.

Condition at discharge, March 28, 1913, 15 days after operation: No complaints. Fundi: Veins possibly slightly enlarged; otherwise negative. Right pupil still larger than left. Knee-jerks present and equal. No Babinski. Possibly some lower left facial weakness (peripheral). Decompression opening flush with rest of scalp; normal pulsation.

June 4, 1914. No complaints. Fundi negative. Some impairment of hearing of left ear, bone conduction being greater than air conduction (middle ear). Working daily.

September 2, 1914. No complaints. Works daily.

CASE 3

———, Hilary. 18 years. College.

Diagnosis: Fracture of the skull; subdural hemorrhage; epilepsy. Operation: Left subtemporal decompression and exploration.

Admitted Polyclinic Hospital, March 21, 1914, 9 P. M. Referred by Dr. T. J. Kearns.

F.H. Negative. No history of epilepsy, insanity or nervous diseases; no alcoholism.

P.H. Negative. No diseases of childhood. Nine months baby; normal delivery. Never had convulsions. Very bright mentally—fifth year Latin. Speaks German French and Greek.

P.I. *Five days ago,* March 16, 1914, while at bat, patient was struck by pitched ball over left temporoparietal region; unconscious for several minutes and was then assisted to his home. No bleeding from ears or nose; no ecchymoses. *Twelve hours later,* patient had an epileptiform attack of 25 minutes' duration; its character was not observed other than it was a general convulsion with frothing at the mouth. Weakness of right arm noticed after this attack. *Eighteen hours later,* second convulsion of the Jacksonian type, beginning in right arm with frothing at the mouth. Since then, patient has had 5 convulsions, last one being 12 hours ago and a most severe one; it began in the right arm, then right side of face, then right leg, and finally a general convulsion resulted.

P.E. March 21, 1914, 4 P. M. T. 99. P. 80. R. 16. Pupils: Left slightly larger than right. No ocular paralysis. Difficulty in talking properly. Definite paresis of right arm; grip of right hand weaker than left. Deep reflexes increased on right side. Right Babinski. Abdominal reflexes: Right less than left. Fundi: Retinal veins dilated; obscuration of disk margins, particularly of the left disk. Paraphasia: Unable at times to find the correct word, and used words incorrectly; patient was conscious of his mistakes. No agraphia. Memory impaired for recent events.

P.E. 9 P. M., on admission to hospital. T. 99.2. P. 78. R. 18. B.P. 140. Paralysis of right arm much increased; right facial paresis; also right leg weaker than left. Reflexes: Right greater than left; definite right Babinski and right patellar and ankle-clonus. Fundi: Same condition as noted above. Mentality more impaired. No convulsions since preceding examination.

Operation, March 21, 1914, 10 P. M., 5 days after injury: Left subtemporal decompression and exploration. Usual incision (rather anterior) and bone removed; bone unusually thin; no complications. No fracture ascertained. Dura under high tension; upon incising it, a little blood-stained cerebrospinal fluid escaped. Cortex very edematous and at the anterior upper portion of decompression opening over the posterior portion of left third frontal convolution, extending backward and upward over the motor area of the face and arm, was a bluish subarachnoid hemorrhagic clot ¼ in. in thickness. Surrounding cortex normal. No attempt made to remove subarachnoid hemorrhage for fear of doing damage to cortical cells. Much cerebrospinal fluid escaped. Usual closure with drains.

P.O. Uneventful. No convulsions. Difficulty of speech lessened rapidly. Paralysis of right arm and weakness of right face and right leg gradually disappeared.

Condition at discharge, March 31, 1914, 10 days after admission and operation: No complaints. No convulsions. No paraphasia. Possibly some slight weakness of right arm. Reflexes: Knee-jerks and biceps, triceps and wrist reflexes of right arm possibly more active than left. No Babinski. Abdominal reflexes: Right equals left. Fundi: Possibly a slight dilatation of retinal veins; otherwise negative.

June 15, 1914. No complaints. No convulsions. No paraphasia. Physical examination negative. No weakness of right arm. Fundi negative.

August 28, 1914. No complaints. P.E. Negative.

Remarks: This case illustrates the advisability of an early operation. Sufficient time naturally has not yet elapsed to ascertain whether or not the patient will enjoy the same good health as before the accident.

B. BILATERAL DECOMPRESSION

Case 1

———, Richard. 41 years. Manager.

Diagnosis: Fracture of base. Subdural and intracerebral hemorrhage. Operation: Bilateral decompression.

Admitted Polyclinic Hospital, December 26, 1913. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. While crossing Broadway at 65th Street crossing, patient and wife were struck by automobile. Wife killed instantaneously. Patient unconscious. Ambulance.

P.E. T. 98.8. P. 130. R. 30. B.P. 110. Semi-conscious. Well-nourished white man. In shock. Reflexes sluggish but apparently equal. Double Babinski. No ankle-clonus. Abdominal reflexes absent. Lacerated scalp wound in occipital region. Fundi: No definite signs of pressure at this time (in shock).

Treatment: For shock. Rectal coffee; warmth. Expectant palliative. *1st day after admission*, shock had disappeared, then patient began to show the signs of intracranial pressure—retinal veins dilated and slight blurring of disks (nasal margins). P. 70. R. 18. Reflexes: Right slightly greater than left. Operation advised but refused. *5th day after admission*, patient became stuporous, delirious and slightly jaundiced; P. 50 and respiration 16, irregular at times. Fundi: Marked dilatation of veins and blurring of entire disks. Reflexes: Right greater than left; double Babinski. Consent for operation obtained.

Operation, December 31, 1913. 5 days after admission: (1) *Right subtemporal decompression.* Usual incision and removal of bone. Dura very tense and upon incising it, dark semi-clotted blood escaped. Tension of cortex extreme but it did not rupture; very small amount of cerebrospinal fluid escaped. Usual closure with drain. Owing to great pressure with little escape of fluid (an almost "dry" brain), a left subtemporal decompression thought advisable and this was immediately performed.

(2) *Left subtemporal decompression.* Usual incision and bone removed. Dura very tense and upon incising it, similar dark clotted blood escaped under great tension. Brain rather "dry"; attempt made to tap ventricle but not successful. Usual closure made with drain, cortex bulging out under great tension.

P.O. *1st day,* patient much brighter mentally—in fact, better than at any time since accident. Talks more forcibly and intelligently. No paralyses. Fundi: Vessels still dilated and nasal margins are blurred. *8th day,* steady improvement. Fundi practically negative. Reflexes increased but equal. No Babinski. Decompression opening still tense.

January 29th, 1914. Patient ready to be discharged but laceration of scalp superficially infected; otherwise negative.

Condition at discharge, January 31, 1914, 36 days after operation: Leaving hospital practically well. Talks intelligently, but rather garrulously—more so than before accident. Reflexes increased but equal. No Babinski nor clonus. Abdominal reflexes present and equal. Fundi negative. Locally, decompression openings not tense.

May 29, 1914. No complaints. Physical examination negative. At work daily.

August 27, 1914. No complaints. Works daily.

Remarks: It is doubtful if a unilateral decompression would have been sufficient to save the life of this patient.

Case 2

———, Frank. 32 years. Mechanic.

Diagnosis: Fracture of base and vault. Subdural and intracerebral hemorrhage. Operation: Bilateral decompression.

Admitted Polyclinic Hospital, March 15, 1913. Referred by Dr. W. S. Bainbridge.

F.H. Negative.

P.H. Negative.

P.I. Patient was knocked down by an automobile—taken to station house; unable to talk, therefore designated on the register as "foreigner." Brought to Polyclinic Hospital in ambulance four hours later.

P.E. T. 101. P. 68. R. 18. B.P. 150. Semi-conscious; easily aroused by supraorbital pressure. Well nourished. Bowels move involuntarily. Pupils small and equal; normal reaction. Bleeding from nose. Hematoma about eyes—more about right. Reflexes: Knee-jerks, right greater than left; Babinski on right; right abdominal reflex not obtained. Fundi: Slight fulness of veins and definite haziness about nasal margins. Expectant palliative treatment. *24 hours after admission:* Condition practically the same. Would not speak or utter a cry. Comatose. T. 100.4. P. 62. R. 16. B.P. 160. Fundi: Vessels dilated; entire nasal halves of disks clouded and obscured. Operation advised, 28 hours after admission.

Operation, March 16, 1913: (1) Left subdural decompression. Incision exposed fracture in squamous portion of temporal bone—fragments movable and removed. Dura very tense and bluish. Dark clots the size of olives welled up through dural opening and also out of rent in the posterior third frontal convolution (motor speech area). Brain so tense that all the clot (subdural) could not be removed. Drain inserted, but very little cerebrospinal fluid escaped at this time, so that the intracranial pressure was not relieved as much as usual. Usual closure.

As patient showed very little improvement after first operation, a decompression was made the following day on right side.

(2) Right subtemporal decompression: Usual incision and removal of bone. Dura and cortex very tense. No subdural hemorrhage on right side. Moderate amount of bloody cerebrospinal fluid escaped. Usual closure with drain. Then the first incision was reopened and practically the entire subdural clot was removed, owing to the intracranial pressure being relieved by the right decompression. Clots the size of a 10-cent piece still welled up from the motor-speech ara. Drain reinserted. Usual closure.

P.O. *2nd day,* drains removed. Rather restless. Sits up in bed. Unable to talk, but will shake hands, etc. Hearing impaired. Reflexes: Knee-jerks exaggerated with tendency to a double Babinski. Fundi: Vessels dilated with blurring of optic disks.

7th day postoperative; patient has not spoken. Understands gestures, but apparently does not hear. Goes to toilet himself.

15th day postoperative; patient has been reading magazine in bed to-day. Temperature normal. Spoke several words to-day.

Condition at discharge, April 12, 1913, 25 days after operation. Talking fairly well. Hearing impaired. Reflexes increased but equal. No Babinski. Fundi: Still slight dilatation of retinal veins; no edema. Locally, decompression areas not tense.

April 28th, 1913, 41st day after operation. Went to work. No complaints. Steady employment as chauffeur. At times, paraphasic. Reflexes increased but equal. No Babinski. Fundi negative. Mentally, apparently normal.

June 2, 1914. No complaints. Working daily as chauffeur. Physical examination negative. Speech practically unimpaired, except for phrases such as "Truly rural," "Around the rugged rock, the ragged rascal ran," etc., when patient slurs the words at times.

September 2, 1914. No complaint. Speech practically normal. Works daily.

Remarks: This case illustrates the necessity of performing a bilateral decompression, if the first operation does not relieve the intracranial pressure sufficiently; ordinarily, this is easily recognized at the first operation, especially if the brain is unusually "dry"; then, the second operation should be immediately performed, unless the condition of the patient will not permit it. Naturally, it is essential in these cases to insert the drain well under the temporal lobe in the middle fossa in order to obtain excellent drainage, so important in these extreme cases.

It is interesting to note the almost complete recovery from the motor aphasia and paraphasia, especially when the lesion of the motor speech area has been definitely observed at operation. In these cases (and I have seen several of them), the impairment of the cortical cells must be one of local compression from the clot and edema rather than one of actual destruction of the cells—otherwise there would be no return of function.

CASE 3

———, Walter. 32 years. Reporter.

Diagnosis: Fracture of base of skull. Extradural and subdural hemorrhage. Operation: Bilateral decompression.

Admitted Polyclinic Hospital, May 6, 1914. Referred by Dr. John A. Bodine.

F.H. Negative.

P.H. Negative.

P.I. Three days ago, patient was struck by an automobile. Unconscious. Ambulance.

P.E. Upon admission to the hospital, patient was in a condition of extreme shock; cold, clammy skin; respirations 4 and 5 per minute—very shallow and hardly perceptible; pulse 124, weak and irregular at times. B.P. 105. No bleeding from ears or nose. Patient was immediately put into a warm bed, the head not being lowered; hot coffee by rectum and the routine treatment for shock begun. After brisk stimulation, patient recovered consciousness within 6 hours; he then vomited and has continued to do so during the past 3 days; has complained of persistent pain in the back of head and neck; has talked incoherently and his mental activity is very sluggish and confused. The pulse gradually descended to 64, and when I examined him on the third day after admission, the pulse was 56.

P.E. May 9, 1914, 8 P. M. T. 100. P. 56. R. 18. B.P. 14.5. Conscious but confused mentally. No paralysis. Reflexes: Right greater than left; right Babinski. No clonus. Abdominal reflexes: Right depressed, but still elicited. Fundi: Double "choked disks"; retinal veins dilated, tortuous and buried in the edematous retina, especially about the disks, which were completely obscured. Immediate relief of pressure advised for fear of a medullary collapse.

Operation, May 9th, 9.30 P. M.: (1) Left subtemporal decompression. Usual incision and removal of bone, which was very hard. No fracture observed. Dura exceedingly tense, and, upon incising it, almost pure dark blood spurted to height of 1 foot; much free subdural blood and cerebrospinal fluid escaped. Cortex over lower temporosphenoidal lobe lacerated and portions of it "oozed out." Cortex over upper temporal lobes in lacerated condition. As the brain itself was comparatively dry, and owing to the high intracranial pressure, a right subtemporal decompression was performed in order to relieve the pressure still more.

(2) Right subtemporal decompression. Usual incision and bone removed; transverse fracture squamous bone observed. Large extradural clot, ½ in. in thickness; it extended beyond the borders of the decompression opening. Dura also tense, and again almost pure dark blood spurted 4 in. upon opening the dura and much cerebrospinal fluid, deeply blood-tinged, escaped; no laceration of cortex. Usual closure with 2 drains of rubber tissue.

P.O. Uneventful recovery. During the first 6 days, patient was a little confused and rebellious. He did not remember anything previous to the operation, although he talked rather intelligently about himself during those 3 days.

2nd day P. O. T. 100.4. P. 76. R. 18. B.P. 140. Drains removed—clear cerebrospinal fluid escaping.

6th day P.O. All sutures removed. Decompression areas tense.

Condition at discharge, May 19, 1914, 10 days postoperative: T. 98.8. P. 80. R. 20. B.P. 128. Patient complains of slight frontal headache at times; otherwise, he feels well. Some mental retardation, although no confusion. Loss of memory for the events of the day preceding the accident and also for the 3 days before the operation. Both decompression areas are rather tense; normal pulsation. Reflexes: Right possibly more active than left; no Babinski. Abdominal reflexes present and equal. Fundi: Some edematous blurring of nasal halves of disks—otherwise negative.

July 7, 1914. No complaints other than a "fulness in the head" at times; rather irritable. No nausea. Patient can now remember some of the events of the day preceding the accident. P.E.: T. 98.8. P. 80. R. 20. B.P. 134. Decompression areas somewhat relaxed and "sunken in"; normal pulsation. Reflexes active and equal; no Babinski; no clonus. Fundi: Some haziness along the nasal margins of the optic disks; retinal vessels normal.

September 2, 1914. No complaints. Works daily.

Remarks: This was a most instructive case of the value of waiting until the severe shock subsided; if the operation had been performed within a short time after admission, it is very probable that the patient would have died. Again, it is doubtful if a unilateral decompression would have sufficed. The left hemisphere must have been more severely damaged than the right, as his reflexes were all more marked on the right than on the left. The immediate rise of the pulse rate following operation is most impressive. Whether this patient will suffer from posttraumatic symptoms is to be observed; in view of the laceration of the cortex, it would not be at all surprising, and yet, with the early relief of the intracranial pressure, he may escape. The absence of bleeding and leakage of cerebrospinal fluid from the ears and nose is rather remarkable; as may happen very frequently, the fracture did not enter these weaker areas of the base of the skull.

Case 4

———, Andrew. 25 years. Clerk.

Diagnosis: Fracture of vault and base. Subdural and intracerebral hemorrhage Operation: Bilateral decompression.

Admitted Muhlenburg Hospital, Plainfield, N. J., November 30, 1913. Referred by Dr. B. Van D. Hedges.

F.H. Negative.

P.H. Always well and strong.

P.I Three days ago, patient collided with a stone wall while riding a motorcycle. Brought to hospital unconscious and in shock. Has not regained consciousness, but within the last 6 hours, very restless and apparently less unconscious. Some bleeding from left ear. Has not attempted to speak.

P.E. December 3, 1913, 3 days after admission: T. 100.6. P. 78. R. 20. B.P. 145. Well-built man of 25 years of age. Both eyes ecchymotic, associated with subconjunctival hemorrhages. Blood clots in left auditory canal. Marked tenderness and edema over left squamous region. Pupils equal and react to light. Apparently no paralyses. Reflexes all increased, especially on right side. Double Babinski, right greater than left. Abdominals present and equal. Fundi: Extreme dilatation of veins and blurring of entire nasal halves of disks. Incontinence of urine and feces. Diagnosis: Fracture of base and vault, marked intracranial pressure with hemorrhage over left cerebral hemisphere; extradural or subdural?

(1) Operation, December 3, 1913, 3 days after admission, 9.30 P. M.: Left subtemporal decompression. Usual incision. Subcutaneous tissues and temporal muscle very edematous and ecchymotic. Large horizontal crack in squamous portion of temporal bone extending forward and backward beyond the margin of the decompression opening. Small extradural clot. Dura very tense and upon incising it, bloody cerebrospinal fluid spurted to a height of 8 to 10 in. for a minute at least. The underlying cortex was very much congested and suffused. The pia-arachnoid "sweating," however, ceased after several minutes, and the brain tended to bulge. Drain placed under temporosphenoidal lobe, allowing much cerebrospinal fluid to escape. Usual closure with drain. At end of operation, P. 88, R. 30, general condition good.

P.O. *1st day.* P. 130. R. 36. Condition poor. Twitching of arms and legs. Gradual improvement, but decompression opening remained tense; mentally very much impaired.

I saw the patient for the second time on December 16, 1913, 13 days after first operation. Patient still semi-conscious; delirious. Reflexes exaggerated, left greater than right. Left Babinski. Fundi: Vessels dilated and nasal halves of disks still obscured. Locally, decompression area tense. To afford a greater relief of pressure, a right subtemporal decompression was advised.

(2) Operation, December 16, 1913, 13 days after first operation: Right subtemporal decompression. Usual incision and bone removed—several linear fractures over squamous portion extending down into ear and base. Dura under tension. Blood-tinged cerebrospinal fluid under high pressure. Cortex showed numerous small hemorrhages in it. Usual closure with drain.

P.O. Marked improvement began immediately; mental impairment lessened daily. Reflexes became less exaggerated and Babinski disappeared.

Condition at discharge, February 2, 1914, 62 days after admission. Occasional headaches—when stooping over. Otherwise, no complaints. Mentally, difficult to concentrate thoughts. Perseveration at times. Easily fatigued. Reflexes active but equal. No Babinski. Fundi: Vessels negative, but new tissue formation at nasal margins of disks; physiological cup shallow.

April 6, 1914. Gradual improvement. No complaints, except rather easily fatigued. Reflexes rather active; equal. Fundi: Vessels are negative; mild secondary optic atrophy.

June 7, 1914. No complaints, though easily fatigued. Talks rather slowly. Mentality rather retarded. At work daily (in office, but work is not arduous). Reflexes still active. Fundi same as at preceding examination.

August 26, 1914. No complaints, though patient tires quickly. "My mind works slowly."

Remarks: In this case, if the second operation had been performed earlier, I think the result would have been better; intracranial pressure prolonged over a period of 10 to 14 days must impair the cortical nerve cells, as illustrated in this case of delayed operation.

CASES OF RECENT FRACTURE OF THE SKULL SHOWING INTRACRANIAL PRESSURE; NO OPERATION; SYMPTOMS AND SIGNS PERSISTING

CASE 1

———, Thomas. 38 years. Laborer.

Diagnosis: Fracture of base of skull. No operation.

Admitted Polyclinic Hospital, November 19, 1913, 8 A. M.

F.H. Negative.

P.H. Negative.

P.I. Patient fell 2 flights down elevator shaft. Unconscious. Ambulance.

P.E. T. 100. P. 128. R. 38. B.P. 120. Well built. Comatose. No laceration of scalp. Contusions over right side of head. Subconjunctival hemorrhage and ecchymoses of right eye. Pupils do not react—moderately contracted (morphin?). Bilateral external strabismus. Bleeding from nose. No paralysis of face, arms or legs. No anesthesia nor hypesthesia. Knee-jerks not obtained. Double Babinski and Oppenheim. Abdominal reflexes present. Respiration labored and difficult. Fracture of fifth and sixth left ribs. Fundi: Retinal veins dilated; blurring of nasal margins of optic disks. *12 hours later:* T. 101.8. P. 164. R. 40. Patient semi-conscious. Right pupil much larger than left, reacts sluggishly. Ecchymoses of right eye remain same but darker. No paralysis. Knee-jerks not obtained; Babinski on left leg. Fundi the same as at the preceding examination.

Treatment: Expectant palliative; hot rectal coffee.

1st day: Gradual improvement. T. 100. P. 130. R. 28. B.P. 135.

2nd day: Patient complains of considerable pain throughout body, especially left side of chest. Has been coughing, raises blood-stained mucus. Emphysema felt over left fourth to eighth ribs anteriorly. Resonance of both lungs good—few râles at left base. Right eye closed by edema and ecchymosed; right pupil larger than left. Pulse 115 and better quality. Knee-jerks absent. Babinski persists on left leg. Fundi: Veins dilated; slight blurring of nasal margin of disks. T. 100.2. P. 130. R. 30.

November 29th. Patient has complained of more or less constant headache. Tenderness over left side of head. Pain in left chest and right hip. No incoördination.

Right pupil still slightly larger than left. Ecchymoses in both eyes now and marked. Ecchymoses detected over left mastoid. Knee-jerks obtained after much difficulty; left Babinski still persists. Fundi: Definite haziness and blurring, especially over nasal halves of disks. A decompression operation advised at this time, but it was refused.

Condition at discharge, December 24, 1913, 34 days after admission: T. 97. P. 68. R. 18. Improved. Headache still present but not so severe. Pupils equal. No pain on breathing. Knee-jerks active but equal; Babinski left leg, not so definite. No paralysis. Fundi: Mild signs of increased intracranial pressure with new tissue formation in the physiological cup and about the nasal margins of disks.

February 2, 1914. Complains of severe headache with a blurring of vision. Reflexes increased but equal; no Babinski. Fundi: Mild signs of secondary optic atrophy.

June 2, 1914. Headache still persists; unable to work. Physical examination same as at preceding examination. T. 99. P. 68. R. 18. B.P. 158.

Remarks: I think it would have been wiser in this case to have performed a decompression (and it was advised) when the patient had recovered from the shock of the injury and was showing definite signs of intracranial pressure. As the patient now desires an operation or "anything to relieve headaches," if the condition persists, I shall perform the operation even at this late date, in the hope of improving him and relieving the headaches.

CASE 2

———, Daniel. 28 years. Conductor.

Diagnosis: Fracture of base of skull. No operation.

Admitted Polyclinic Hospital, December 16, 1913.

F.H. Negative.

P.H. Negative.

P.I. Patient was struck on left side of head by an automobile, while alighting from a trolley car. Unconscious. Ambulance.

P.E. T. 98.2. P. 94. R. 17. B.P. 125. Well built. Unconscious. Pupils: Right larger than left; react normally. No bleeding from ears. Lacerated scalp. Abdominal reflexes present and equal. Knee-jerks active and equal; right Babinski. Headaches and vomiting. Fundi showed dilated veins and blurring of nasal halves of disks. Operation advised and refused. *4 hours later.* T. 98. P. 58. R. 18. Expectant palliative treatment.

Condition at discharge, December 24, 1914: Patient refused to remain in hospital. T. 98. P. 60. R. 18. B.P. 145. Pupils react normally. No paralysis. Reflexes: Right possibly greater than left; tendency to a Babinski in right leg. Still has some headache and nausea. Fundi same as at preceding examination.

January 3, 1914. Feels fairly well; has resumed work. Has slight headache.

January 14, 1914. Patient complains of rather severe headaches and nausea at times. Dizzy. Unable to work. Says he would like an operation now.

March 3, 1914. Severe headaches; unable to work. Reflexes all increased; no Babinski. Fundi: Veins dilated; new tissue formation about the margins and in the physiological cup.

June 5, 1914. Unable to work on account of headaches. Physical examination: Condition same as at preceding examinations.

August 17, 1914. Headache persists but not so severe.

Cases of Old Fracture of Base of Skull; No Operation; Symptoms and Signs Persisting

Case 1

———, Andrew. 37 years. Carpenter.

Examined at the Polyclinic Hospital, March 28, 1914. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. On September 30, 1913 (6 months ago), scaffold upon which patient was working broke and patient fell 45 ft. upon back and head; in hospital for 1 month. Unconscious 2½ days. Since then, pain in temples and back. Beginning blindness in left eye. Slight dizziness upon bending over. Easily excited. Memory impaired, especially for events of past 2 years.

P.E. Rather poorly nourished Scotchman. Pupils: Left greater than right; left pupil rather sluggish to light. No paralyses or anesthesias. Reflexes all very much increased; patellar and exhaustible ankle-clonus. No Babinski but slight plantar flexion. Abdominals: Right greater than left. Vision: Right 9/10; left 1/100 (almost blind in this eye). Fundi: Retinal veins dilated; definite secondary optic atrophy—more in left eye where there is pigment or old hemorrhage over the macula lutea (old hemorrhage of the central retinal artery). Speech fair; no definite slurring. Hearing fair; right better than left; Weber's test—referred always to left. Rinne's—AC greater than BC in right ear. Definite and marked tremor of both hands, especially of the intentional type. Slight swaying—tendency to Romberg. Memory impaired for past events, two years or more. Very irritable.

Remarks: It is doubtful if an operation at this late date would improve the patient's condition other than to lessen and even relieve the headaches and irritability. Naturally the impairment of vision will be permanent.

Case 2

———, Frank. 10 years.

Diagnosis: Traumatic dementia following severe fracture of base of the skull.

March 22, 1914. Seen in consultation. Referred by Dr. E. W. Lawrence.

F.H. Negative. No insanity or nervous taint in the family of either parent. Two other children well and strong.

P.H. Always well and strong. Nine months baby; normal delivery. No serious children's diseases. Bright boy in school.

P.I. On December 6, 1912, patient was struck by a street car; unconscious for 8 hours. Bleeding from both ears; vomiting of much blood. General convulsions for 7 days; not Jacksonian in type. Since then, very quiet, sullen, refuses to speak, holds head down. Dirty habits. Resists all attempts to move him. Patient must be fed forcibly, as he will remain 24 hours without eating.

P.E. Very sullen. Holds head down. Reflexes obtained with difficulty; tendency to a Babinski on left. Fundi: Definite signs of old pressure observed in the new tissue formation about the nasal margins of the optic disks and the shallow physiological cups; veins still dilated; nasal margin of disks blurred; right disk rather pale. Some internal strabismus. Mentally: Unable to make a thorough examination as patient resisted all attempts.

Remarks: If it were not for the definite signs of old intracranial pressure as revealed by the ophthalmoscope, this case might be one of traumatic hysteria or a case of incipient dementia præcox; considering the history and the physical signs, it is most likely a case of multiple punctate hemorrhages in the cortex, producing this clinical entity of traumatic dementia. Whether this condition could have been lessened and possibly avoided by an immediate relief of the intracranial pressure following the accident is questionable; at any rate, an early operation is always advisable in these cases of pronounced intracranial pressure.

Case 3

———, Harriet. 48 years. Housewife.

Diagnosis: Fracture of base of skull. No operation. Symptoms and signs persisting.

Admitted White Plains Hospital, June 9, 1913. Referred by Dr. G. S. Amsden, White Plains.

F.H. Negative.

P.H. Negative.

P.I. On June 9, 1913, patient was injured in an automobile accident. Unconscious. Taken to hospital. No bleeding from ears, eyes or nose. Knee-jerks were much exaggerated; double Babinski present. T. 100 P. 90. R. 24.

Patient was seen by me on June 11, 1913, 2 days after accident. T. 99.8. P. 94. R. 22. B.P. 145. Well-nourished white woman. Unconscious, but could be roused by supra-orbital pressure; unable to reply to questions. No apparent paralyses. Pupils equal and react normally. Right subconjunctival hemorrhage; right orbital ecchymoses. Reflexes increased; left possibly greater than right; left Babinski. Abdominal reflexes not obtained, the abdominal wall being fat. Fundi: Definite dilatation of retinal veins, with blurring of the nasal halves of the optic disks, especially the right disk.

As it seemed that the condition of the patient was improving, especially the unconsciousness, which was becoming lighter more of a comatose condition - I did not urge an immediate decompression, although I advised it, not for fear the patient would die, but rather to avoid the posttraumatic conditions. It was decided to await developments.

The patient gradually became conscious 5 days after the accident (June 14th); I examined her again at this time: T. 99. P. 84. R. 22. B.P. 140. Knee-jerks exaggerated; left possibly greater than right; left Babinski - easily exhausted. Fundi same as at preceding examination. Marked paraphasia, sensory as well as motor, which lasted 2 weeks. Amnesia present for 20 days—then gradually improved.

July 10, 1913, 31 days after accident. Easily fatigued; distressed by any noise. Frequent dull headaches. Poor memory for proper names still persists. Reflexes increased, but equal; no Babinski.

January 1, 1914. When tired, patient complains of discomfort in head—a sense of pressure; occasional spells of dizziness. Rarely perseveration in the use of words. Memory for names still impaired. Restlessness with insomnia at times. No marked changes in temperament—possibly more irritable. Knee-jerks increased, but equal. No Babinski. Slight tremor of both hands. Tendency to a Romberg. Slight ataxia of both hands, especially the left. Fundi: Mild signs of old intracranial pressure—slight haziness about the nasal margins of the optic disks; shallow physiological cup from new tissue formation with rather pale disks; vessel walls thickened but no abnormal dilatation of the vessels themselves.

June 1, 1914. Still complains of heaviness and fulness in the head, especially upon exertion or when fatigued. Memory for recent events not so good as before the injury. No definite change in personality. Reflexes very active; no clonus or Babinski. No impairment of vision other than a subjective blurring and haziness; fundi same as at preceding examination. Slight paraphasia at times—frequently unable to use well-known words.

Remarks: It will be most interesting to observe this patient for a number of years in order to ascertain the permanent impairment; she may entirely recover, and yet it would be surprising if she did so. Posttraumatic conditions of this type are most persistent. I now feel that I should have advised a decompression at my first examination more vigorously than I did; in my opinion, it would have been the safer procedure.

Cases of Old Fracture of Base; Epilepsy; Decompression

Case 1

——, Henry. 20 years. Sailor.

Diagnosis: Old fracture of skull; epilepsy. Right subtemporal decompression.

Admitted Polyclinic Hospital, October 20, 1913. Referred by Dr. Joseph E. Engelson.

F.H. Negative.

P.H. Negative.

P.I. One year ago, patient fell from main-mast, a distance of 20 feet, upon top of head. Unconscious; bleeding from both ears. Taken to Marine Hospital, remaining 10 days—unconscious most of the time. Discharged on the 12th day after accident. Fainted upon reaching home—having severe headaches and persistent vomiting. Since then, patient has "fainted" 2 or 4 times each day, associated with a general convulsive seizure. Severe headaches. Dizzy at times. Hazy vision, becoming worse. Hearing negative.

P.E. Well-built negro. Head, negative. Reflexes increased but equal. Tendency to Babinski on left. Fundi: Retinal veins dilated with slight blurring of nasal margins of disks; physiological cup filled with new tissue; mild secondary optic atrophy.

Operation, October 21, 1913: Right subtemporal decompression. Usual incision and removal of bone (which was typically "ivory" and thick). No complications. Dura very tense, indurated and fairly vascular. Much cerebrospinal fluid escaped; pia-arachnoid "sweating." Numerous adhesions between pia-arachnoid and dura; these were severed. Cortex swollen and edematous. Usual closure. Drains.

P.O. Negative. No headaches. No attacks.

Condition at discharge, October 27, 1913, 7 days postoperative: No complaints. Fundi: Vessels not dilated; mild secondary optic atrophy.

May 16, 1914. No complaints. No headache or fainting spell; no seizures. Fundi: Veins not dilated; mild secondary optic atrophy. At work.

August 27, 1914. No complaints. No convulsions nor headaches. At work daily.

Case 2

——, Abe. 15 years. Student.

Diagnosis: Old fracture of skull. Epilepsy. Operation: Left subtemporal decompression and exploration.

Admitted Polyclinic Hospital, February 31, 1914. Referred by Dr. A. F. Stoloff.

F.H. Negative. No history of alcoholism, insanity or epilepsy.

P.H. Negative. Always well and strong.

P.I. Six years ago, patient was struck over head by bottle, lacerating scalp. No loss of consciousness, merely dizzy; slightly nauseated. Walked home. Went to school next day. Two months later, patient had a general convulsion. Three months later, patient had another general convulsion and since then, patient has had as many as 3 or 4 "spells" during each night; when frightened or scared, he would have them of Jacksonian character. During past 2 years, convulsions have been much more frequent, all beginning in the right hand and right side of face and then the entire body; they last 3 or 4 minutes. Has been cross, irritable and very nervous. Vomiting often; bowels regular. Persistent frontal headaches all the time and this is his chief complaint. Memory good. At times, paraphasic, especially following attacks. No improvement with medication of all kinds.

P.E. Scar over left forehead; no depression ascertained. Definite paresis of right arm. Fundi: Vessels dilated; definite blurring of nasal margins of disks. Wassermann, luetin, and cerebrospinal fluid cell count negative. Reflexes: Knee-jerks, right greater than left; tendency to a right Babinski. Right abdominal reflexes depressed.

Operation, February 5, 1914: Left subtemporal decompression and exploration. Usual incision, though slightly anterior. Removal of bone, which was unusually thick; no complications. Dura thickened and tense. Edematous cortex tending to protrude; in sulci were definite signs of old hemorrhage—bluish areas of organized blood clot with numerous adhesions to overlying dura. Vessels rather whitish. Arachnoid indurated in sulci. Usual closure with drains.

P.O. Uneventful recovery.

Condition at discharge, February 14, 1914, 8 days postoperative: No complaints other than an occasional fulness in the head. No "spells." Reflexes: Right tend to equal left. Fundi: Retinal vessels not dilated; otherwise, the same as at preceding examination.

June 6, 1914. No complaints. Works daily (stage). No spells since operation. Physical examination negative, except for scar tissue formation in the fundi, as disclosed at preceding examinations.

Remarks: It is unusual for epileptiform attacks to cease, especially when they have occurred over a period longer than one year; the "epileptic habit" is usually acquired, and the attacks will continue even after the original exciting cause, whether it be a fragment of bone, a blood clot or foreign body in the cortex, has been removed. However, the earlier the operation, the better is the chance for a complete recovery. Naturally, sufficient time has not yet elapsed in this case to warrant a permanent cure.

Case 8

———, John. 38 years. Laborer.

Diagnosis: Old fracture of the skull. Epilepsy. Motor aphasia. Operation: Left subtemporal exploration and decompression.

Admitted Polyclinic Hospital, May 16, 1914. Referred by Dr. E. S. Bishop.

F.H. Negative.

P.H. Seven months ago, while loading a boat, patient was struck on the head by a bucket of coal; a "watery fluid" trickled from left ear. Walked home; unable to speak for 3 days. Since then, patient has had continuous headaches, so that he has been unable to work more than one or two days, and then "lays off" for the rest of the week. Pain in left frontal region; no nausea or vomiting. Bowels regular daily. Not alcoholic. *Two months ago,* patient had the first convulsion; apparently general in character with twitchings lasting for 6 hours; involuntary micturition. *Ten days later,* the second convulsion occurred but was limited to the right side of the body, beginning in right side of face, then right arm and then right leg; attack lasted 25 minutes. There has been a distinct change of disposition—much more irritable and very forgetful of recent events. Complained bitterly of headaches, which have continued up to the present time.

P.I. Three weeks ago, after a severe headache, convulsions began in the right side of face and then extended to right arm and leg; patient has had 7 and 8 attacks each day. Unable to speak a word—a pure motor aphasia; no agraphia.

P.E. May 17, 1914. T. 100. P. 80. R. 22. B.P. 145. Apathetic. Unable to speak; merely nods head. Right arm much weaker than left; right side of face lags. Reflexes: Right greater than left. No Babinski. Abdominal reflexes: Right diminished. Fundi: Blurring of optic disks, especially the nasal halves; retinal veins dilated. Wassermann test of blood and cerebrospinal fluid negative.

Operation, May 22, 1914: Left subtemporal decompression. Usual incision and bone removed; no fracture ascertained. Rather high degree of dural tension; dura incised, allowing a large amount of cerebrospinal fluid to escape. Typical pia-arachnoid "sweating." Whitish induration of cortical veins with numerous adhesions between pia-arachnoid and dura; these were severed. Usual closure.

P.O. Uneventful. Triple bromides gr. 15 t. i. d. for 4 days. No convulsions. Speech slightly improved; can now say several simple words.

Condition at discharge, June 4, 1914, 12 days postoperative: No complaints other than a "heaviness" in his head. No convulsions. Wound healed. Still some weakness of right arm, but right side of face does not lag. Reflexes: Right still more active than left. Abdominal reflexes, however, respond equally well. Fundi: Retinal veins not dilated; still some blurring of the nasal halves of optic disks. Difficulty in using simple words properly; misplaces them and uses the words incorrectly; he is conscious of his mistakes. No agraphia. Whereas, before the operation, the patient had a motor aphasia, now he is paraphasic, and his improvement continues daily.

July 6, 1914. Improvement continues. No convulsions. Still paraphasic, but much improved. Reflexes active but equal. Fundi: Retinal veins negative; the blurring of the nasal margins of the disks still persists.

FRACTURE OF BASE WITH HIGH INTRACRANIAL PRESSURE NOT DUE TO LARGE HEMORRHAGE; DECOMPRESSION

CASE 1

———, Vincent. 28 years. Mechanic.

Diagnosis: Fracture of base of skull. Operation: Right subtemporal decompression.

Admitted Polyclinic Hospital, June 2, 1913. Referred by Dr. J. A. Bodine.

F.H. Negative.

P.H. Negative.

P.I. Patient fell down 2 flights through an open ceiling. No known loss of consciousness. Was able to walk into ambulance. Except for severe headache and a feeling of giddiness, patient says he "feels all right."

P.E. T. 99.2. P. 64. R. 16. B.P. 145. Well nourished. Bleeding from right ear; none from nose. Vomiting, though no nausea. Not alcoholic. Semi-conscious. Fundi: Marked fulness of veins and definite edema of nasal halves of disks. Reflexes very much increased. No definite Babinski. Abdominals still present and equal. No paralysis nor anesthesia. Right auditory nerve deafness. Lumbar puncture: Cerebrospinal fluid clear, but under high pressure. Patient gradually became comatose and then unconscious 4 hours after admission. T. 100. P. 60. R. 16. B.P. 160.

Operation, June 2, 1913, 6 hours after admission: Right subtemporal decompression.

Usual incision and removal of bone. No complications. Marked escape of clear cerebrospinal fluid upon incising dura, which was very tense and non-pulsating, and the pia-arachnoid was nicked in 2 places allowing the subarachnoid cerebrospinal fluid to escape in 2 small fountains of 3 in. in height; these continued spurting for 3 minutes. Brain very tense but edematous, so that an immediate decompression upon the other side thought unnecessary. Drain pulled out accidentally at close of operation and reinserted blindly. Usual closure.

P.O. *12 hours later:* P. 60, full but regular. R. 16. B.P. 160. *24 hours later:* P. 55, full but regular. R. 16. B.P. 160. *30 hours later:* P. 50, full, but irregular at times; stuporous. R. 14 and slightly irregular. B.P. 170. For fear of an intracranial hemorrhage, it was thought advisable to open wound.

Second operation, 30 hours after first operation: Wound opened but no blood clot found. Ventricle tapped and about 1 oz. of blood-tinged fluid escaped—not under pressure. No complications. Wound closed with drain.

P.O. Pulse continued about 55 to 50—once 48. R. 16 to 18, but regular. The decompression opening remained tense until the 10th day, when it gradually lessened in fulness.

Condition at discharge, June 15, 1913, 13 days postoperative: Complains of occasional frontal headaches—"Things get black at times before my eyes." General malaise. No paralysis. Reflexes all increased; right possibly greater than left. No Babinski. Right auditory nerve deafness still present. Fundi practically negative; slight fulness of veins.

Since then, condition has gradually improved so that now (June 10, 1914) the patient has no complaints except occasional frontal headache; the physical examination is negative, except for a continued dilatation of the retinal veins and rather excitable reflexes.

Remarks: It would have been wiser to have performed a bilateral decompression at the time of the first operation to offset the effects of the very high intracranial pressure. It will be most interesting to follow this case.

CASE 2

———, Edwin. 5 years.

Diagnosis: Fracture of base of skull. Operation: Right subtemporal decompression. Admitted Polyclinic Hospital, June 2, 1913. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. Three and a half hours ago, patient was knocked down by an automobile. No known loss of consciousness. Cried a great deal and then became drowsy. Bled from right ear and a small amount of cerebrospinal fluid observed. No vomiting. Ambulance.

P.E. T. 100.2. P. 68. R. 18. B.P. 115. Semi-conscious. Well-nourished white child. Many contusions over face and head. No paralysis. Right eye ecchymosed. Reflexes much increased; double Babinski. Abdominal reflexes absent. Fundus: Veins full with definite haziness and edema over the nasal halves of the disks. Lumbar puncture showed clear cerebrospinal fluid under high tension; only small amount of fluid allowed to escape for fear of medullary compression.

Operation, June 2, 1913, 6 hours after admission: Right subtemporal decompression. Usual incision and removal of bone; no complications. Upon incising dura, which was under much tension, the cerebrospinal fluid (slightly blood-tinged) spurted a couple of inches, and in enlarging the dural incision, I knicked the pia-arachnoid, through which opening the cerebrospinal fluid spurted to a height of 3 in. and continued to do so for 3 minutes; a second opening in the pia also spurted similarly. The greatest cerebral tension I have yet seen in a fracture case (similar to Case 1). Rubber tissue drain inserted under right temporosphenoidal lobe. No complications.

P.O. Excellent recovery. Drain removed on 2nd day.

Condition at discharge, June 16, 1913, 14 days postoperative: No complaints. Reflexes normal. Fundi negative.

December 4, 1913. No complaints. Physical examination negative.

June 7, 1914. No complaints. Physical examination negative. It seems that new bone is forming over the decompression opening—slightly bulging, with its convexity pointing outward. This formation of new bone over the decompression opening has occurred in several of the youthful patients.

Remarks: The lumbar puncture in this case obtained clear cerebrospinal fluid, and yet there was a definite intracranial subdural hemorrhage, although not profuse.

Case 3

———, Mary. 4 years.

Diagnosis: Fracture of base of skull. Operation: Right subtemporal decompression.

Admitted Polyclinic Hospital, May 23, 1913. Referred by Dr. J. A. Bodine.

F.H. Negative.

P.H. Negative.

P.I. Three hours ago, child struck by an express wagon, and knocked down. No known loss of consciousness. Bleeding from right ear. Vomiting. Very drowsy. Ambulance.

P.E. T. 100.4. P. 66. R. 16. B.P. 140. Well-nourished white child. Knee-jerks active; right possibly greater than left. Tendency to a Babinski on right. Abdominals present, right posibly greater than left. Right ear drum torn and bleeding; no cerebrospinal fluid observed. Fundi: Definite fulness of vessels with slight haziness over the nasal halves of both optic disks. Lumbar puncture: cerebrospinal fluid slightly blood-tinged and under much pressure; only 6 c. c. removed.

Operation, 3 hours after admission: Right subtemporal decompression. Usual incision made and bone removed; no complications. Dura very tense. Upon incision, the cerebrospinal fluid spurted out striking me in the left eye (a distance of 9 in.) and then passing beyond my head to a distance of 1 ft. in all. Opening was enlarged, revealing a very edematous, swollen brain. The cerebrospinal fluid was slightly blood-tinged. The intracranial pressure rapidly diminished. Drain. No complications.

P.O. 2d day, drain removed. No complications.

Condition at discharge, June 5, 1913, 12 days postoperative: No complaints. Physical examination negative. Fundi negative.

June 4, 1914. No complaints. Physical examination negative. New bone is also forming over the decompression opening in this case.

August 27, 1914. No complaints.

Case 4

———, James. 24 years. Conductor.

Diagnosis: Fracture of base of skull. Operation: Right subtemporal decompression.

Admitted Polyclinic Hospital, May 1, 1913. Referred by Dr. John A. Wyeth.

F.H. Negative.

P.H. Negative.

P.I. One hour before admission, patient fell from a subway train, upon the tracks, striking head. No bleeding from ears or nose. Semi-conscious. Ambulance.

P.E. T. 98.8. P. 60. R. 18. B.P. 160. Well-nourished man. Rather stuporous. Answers questions drowsily. Pupils equal and react normally. Knee-jerks: Right slightly greater than left. Suggestion of right Babinski. Right abdominals depressed. No paralysis. Fundi: Vessels full and dark; blurring of nasal halves of disks, especially of left. Lumbar puncture: Slightly blood-tinged and under high pressure; 5 c. c. removed; pathological report—numerous red blood cells. Locally, suspicious indentation of skull and hematomata in upper parietal region of left side, left posterior parietal area and in occipital region over the occipital prominence.

Operation, 2 hours after admission: Right subtemporal decompression. Usual incision made and bone removed; no complications. Dura exceedingly tense. Brain tended to extrude but cortex did not rupture. Much cerebrospinal fluid "sweats" through pia-arachnoid; slightly blood-tinged; typical edematous "wet" brain. Ventricle not tapped. Drain inserted beneath temporosphenoidal lobe. Usual closure.

P.O. May 3, 1913, first dressing. Drain removed. No complications. Patient still drowsy, but no headache or complaints. Fundi: Still enlarged retinal veins and some edema along the nasal margins of the optic disks.

Condition at discharge, May 13, 1913, 12 days postoperative: No complaints. Wound healed; decompression area flush with surrounding scalp; pulsates. Reflexes still increased, but equally so. No Babinski and yet no plantar flexion. Abdominal reflexes present and equal. Fundi: Still some dilatation of veins but no edema observable.

January 4, 1914. No complaints. Physical examination negative. Fundi negative.

June 6, 1914. No complaints. Physical examination negative.

September 2, 1914. No complaints. At work daily.

Remarks: The intradural tension was so high in this case that it would have been extremely dangerous to have performed a left subtemporal decompression, that is, the danger of the cortical cells of the left hemisphere, especially of the motor speech area, being damaged by a protrusion of the cortex at the site of the decompression opening and against the bony margins of the decompression. This danger is greater when the brain is a comparatively "dry" one, a rare condition in fractures of the skull.

CASES OF SEVERE FRACTURE OF SKULL; SUBDURAL AND INTRACEREBRAL HEMORRHAGES; DECOMPRESSION; DIED; AUTOPSY

CASE 1

———, Daniel. 41 years. Longshoreman.

Diagnosis: Fracture of base of skull, especially subtentorially. Operation: Right subtemporal decompression. Died 18 hours after operation.

Admitted Polyclinic Hospital, October 22, 1913, at 8 A. M.

F.H. Negative.

P.H. Negative.

P.I. Patient was said to have been struck by a street car. Unconscious. Ambulance.

P.E. T. 98. P. 120. R. 28. B.P. 120. Rather obese white man. In shock. Alcoholic. Laceration over external occipital protuberance, 1½ in. in length; no definite fracture ascertained. Bleeding from right ear. Pupils: Right greater than left. Fundi: Negative (due to shock?); vessels not dilated. Knee-jerks present and equal. No Babinski. *10* A. M. T. 101.4. P. 134. R. 34. B.P. 120. Slight convulsion of left face and arm. *12* A. M. T. 103.4. P. 140. R. 40. B.P. 110. Had another convulsion limited to the left side of body, lasting 3 minutes. Fundi negative. *3* P. M. Another and another convulsion, continued every 15 minutes until at 5.30 P. M., when they were finally checked by chloroform, morphin, bromids and chloral by rectum. Patient was *in extremis*—atropin, cupping, intravenous and extensive stimulation was applied. An operation was advised in the hope that an improvement might occur—his only chance. (?)

Operation, October 22, 1913, 8.30 P. M. Right subtemporal decompression. Usual incision and removal of bone. No complications. No epidural clot. Moderate tension present. Blood-tinged cerebrospinal fluid welled out of incision in dura. Many subdural clots; cortex congested. Ventricular tapping negative. Usual closure. Patient in poor condition.

P.O. Patient gradually became worse. T. 106. P. 160. R. 44. B.P. 90. Died October 23, 1913, 2.30 P. M., 18 hours after operation.

Autopsy: Laceration 1½ in. long and ½ in. wide below external occipital protuberance. Hematoma at site of wound. Blood in right ear. Ecchymoses and subconjunctival hemorrhages of both eyes. Line of fracture found radiating from external occipital protuberance downward in median line across foramen magnum and up basilar process of occipital bone to dorsum sellæ. Definite small hemorrhages under bony wall of both orbits between the periosteum and the bone, greater in right; same condition above tympani. No epidural hemorrhage. Extensive laceration and cortical hemorrhage of both frontal lobes, particularly right. Hemorrhage and clots (subdural) about cerebellum—posterior to medulla oblongata. Ventricles free. Openings in orbits and both middle ears disclosed clots.

Remarks. This case is instructive in that the patient was suffering from such a degree of shock that the intracranial pressure could not reach a high degree, owing to the lowered blood pressure due to the shock; therefore, the fundi were negative. This case also illustrates the futility of operating upon fractures of the skull when severe shock is present sufficient to elevate the pulse rate beyond 110, and to lower the blood pressure to 110 or less. An operation at this period will only increase the degree of shock and so hasten the end; at least, it can do no good. It is much wiser to wait until the shock is overcome and then the signs of intracranial pressure will appear and they can then be relieved by a decompression. If the patient is seen immediately after the accident, then there may be definite signs of intracranial pressure, but, as a rule, shock supervenes very quickly in the most severe cases.

This case is another example of fractures occurring below the tentorium about the foramen magnum; not only is the shock severe in these cases, but a subtemporal decompression relieves the intracranial pressure less than in the supratentorial lesions. If the patient is only in a mild degree of shock, then a suboccipital decompression may be used; however, this operation is much more formidable than the subtemporal decompression, and unless the patient is in fair condition, it should not be attempted. Of the 9 deaths in my series of 36 operated cases at the Polyclinic Hospital for the year ending June 1, 1914, 4 of them at the autopsy disclosed subtentorial fractures. In my opinion, these fractures are the most frequently fatal of all fractures of the skull.

The small hemorrhages occurring between the bony wall of the orbital plates at the base of the skull and its covering of periosteum frequently occur without a fracture of the overlying bone—merely a rupture of either the periosteal lining or its blood-vessels. If this hemorrhage extends far enough forward, a subconjunctival hemorrhage may appear, and yet there may be no real fracture of the orbital bone. (A similar hemorrhage frequently occurs at the upper portion of the tympanum.)

Case 2

———, Joseph. 42 years. Blind. Newsboy.

Diagnosis: Fracture of base and vault. Subdural and intracerebral hemorrhage; ventricular hemorrhage. Operation: Left subtemporal decompression. Died. Autopsy.

Admitted Polyclinic Hospital, November 8, 1913.

F.H. Negative.

P.H. Negative.

P.I. Patient was struck by an automobile. Unconscious. Ambulance.

P.E. T. 103.6. P. 128 (weak; was 90 before admission). R. 42. B.P. 120. Very obese blind man. No alcoholism. Unconscious. Breathing labored and heavy. Multiple lacerations over posterior portion of scalp. Bleeding profusely from left ear. Large hematoma over left occipital region. Pupils equal; no reaction to light. Fundus: Typical double "choked disk" of 2 diopters. Knee-jerks present but greatly exaggerated; right slightly greater than left. Slight right Babinski. Abdominal reflexes not elicited.

Operation, November 8, 1913, 2 hours after admission: No anesthetic necessary. Left subtemporal decompression. Usual incision and bone removed; no complications. Dura very tense; bloody cerebrospinal fluid spurting 1 in. upon incising dura. Few free clots size of 10-cent pieces lying upon cortex. Brain very edematous, swollen and bulging. Ventricular tapping allowed 3 oz. of bloody cerebrospinal fluid to escape. Usual closure with drains. Patient put back to bed in bad shape and died 2 hours later.

Autopsy: Laceration of scalp over right external occipital protuberance; large hematoma in each temporal muscle. Three lines of fracture found radiating from the right external occipital protuberance toward the right mastoid region and into right middle fossa. No extradural hemorrhage. Extensive laceration and cortical hemorrhage of right frontal lobe and to less extent the left. Hemorrhage and laceration extending over left cerebrum and including Sylvian fissure. No definite basal hemorrhage. Ventricles contained bloody cerebrospinal fluid.

Remarks. This case also illustrates the futility of operating upon cases of fracture of the skull suffering from either severe shock or after an impairment or loss of compensation of the medulla has occurred; in such cases, any operative procedure merely increases the shock and hastens the exitus. It is a great temptation to operate in the belief that the operation is giving the patient his only chance to recover, but, in my opinion, it is better judgment in such cases to postpone the operation in the hope that the shock and the impairment of compensation will be overcome.

The autopsy findings of extensive laceration and hemorrhage of the frontal cortex (opposite to the occipital area of contact) are extremely interesting and of fairly frequent occurrence; we are reminded of "trauma au contre coup."

Case 3

———, Peter. 29 years. Butler.

Diagnosis: Fracture of base and vault. Subdural hemorrhage and lacerations of cortex. Operation: Right subtemporal decompression. Died 24 hours after operation.

Admitted Polyclinic Hospital, November 1, 1913.

F.H. Negative.

P.H. Negative.

P.I. Patient was found lying on the sidewalk; unconscious. Ambulance.

P.E. T. 97. P. 50. R. 16. B.P. 140. Alcoholism. Comatose. Will not speak. Reflexes absent. No Babinski. Fundi: Dilated retinal veins; no definite edema of disk margins. Ecchymoses in right orbit developed 6 hours after admission. Remained in same condition until 2 days later, when respiration became labored and stertorous. Reflexes: Left greater than right. No Babinski. Fundi showed pressure; dilated retinal veins with blurring of nasal halves of optic disks. T. 102. P. 68. R. 20. B.P. 130.

Operation, November 3, 1913, 48 hours after admission: Right subtemporal decompression. Usual incision and bone removed; no complications. Dura very tense. Brain very edematous and "sweating"; much bloody cerebrospinal fluid escaped. Small epidural and subdural hemorrhages. Ventricular puncture negative. Usual closure with drains.

P.O. Patient gradually became weaker and weaker. 10 hours later. T. 102.4. P. 130. R. 44. B.P. 115.

Died, November 4, 1913, at 10 P. M., 24 hours after operation.

Autopsy: No laceration of scalp. Large hematoma 2 in. in diameter under periosteum over right occipital bone. Several small hematomata in right frontal region. Fracture found radiating from a point 1 in. to right external occipital protuberance and ½ in. below, and encircling head longitudinally to a point 1 in. posterior to external orbital process; also to left to point ½ in. above left external auditory meatus. Fracture typical bursting type, the external line being markedly more prominent, while the internal line of fracture was absent several times. At ¾ in. from point of contact was a spreading fracture situated anteriorly about 1½ in. in length. Another fracture downward and forward 1 in. toward mastoid. No epidural clot. Laceration of left frontal lobe and the upper part of left temporosphenoidal, an area 2 in. in diameter. Cortical hemorrhage between dura and anterolateral surface of left frontal lobe. No cortical hemorrhage or laceration over right side of brain. Ventricles free. No basal hemorrhage.

Remarks: Undoubtedly, an earlier relief of the intracranial pressure might have afforded this patient an opportunity to recover; as it happened, the alcoholism so masked the true intracranial condition that the symptoms and signs of intracranial pressure were not observed until 48 hours after admission; it was then too late, as medullary edema and loss of compensation had then occurred.

These "bursting" fractures of the vault are interesting at autopsies in that frequently, as Dr. O. H. Schultze has mentioned, it is easily observable that the middle portion of the "bursting" line of fracture or "crack," is much wider than either of the end portions, showing that the fracture is really the mechanical result of approximating the pole of contact and its opposite pole, so that it "bursts" or "cracks" in its thinnest and weakest meridian; it was true in this case.

CASE 4

———, Mrs. H. G. 45 years. Housewife.

Diagnosis: Fracture of vault and base of skull. Extradural, subdural and intracerebral hemorrhage; cortical lacerations. Operation: Bilateral decompression. Died 78 hours after admission.

Admitted New Rochelle Hospital, November 8, 1913. Referred by Dr. John B. Walker.

F.H. Negative.

P.H. Always well and strong.

P.I. Five hours previous, patient was struck by an auto truck. Unconscious. Ambulance.

P.E. T. 100.6. P. 128. R. 30. B.P. 100. Rather obese woman of 45 years of age. Unconscious. Bleeding from right ear, tympanic membrane being ruptured posteriorly, as revealed by the otoscopic examination. Reflexes all abolished. Fundi: Retinal veins dilated with blurring of nasal margins of optic disks. Fracture of the third, fourth, fifth and sixth right ribs, with emphysema of surrounding tissues and the right side of neck. Fracture of the right patella, also of metacarpal bones of the right hand. Pulse 128, rapid and weak, with stertorous, labored respirations. It was decided wiser to wait to see if the patient could survive the shock. Expectant palliative treatment.

November 9th, 5 P. M., 24 hours after admission. Pulse 109 and slightly better quality. Irregular Cheyne-Stokes respiration. Blood pressure has risen from 110 to 140. Reflexes all increased; double Babinski. Fundi: Early "choked disk"; temporal margins of optic disks just visible; retinal vessels tortuous and buried in edematous retina. Decompression operation advised.

Operation, November 9, 1913, 8 P. M.: Right subtemporal decompression. Usual incision and bone removed; no complications. Extradural clot, the size of a silver dollar, removed. Dura very tense and, upon incising it, much bloody cerebrospinal fluid spurted under high pressure. Cortex was very edematous and "sweated"; small punctate hemorrhages throughout. Right ventricle was tapped and 1 oz. of bloody cerebrospinal fluid was obtained. Usual closure with rubber tissue drain inserted beneath the right temporosphenoidal lobe to drain the middle fossa.

P.O. Patient became conscious ½ hour after the operation. Definite motor aphasia. Condition continued to improve until 18 hours later, when patient gradually became stuporous and then unconscious—rapidly becoming worse. Left decompression advised. T. 101.4. P. 98. R. 20. B.P. 135.

2nd operation, November 10, 9 P. M.: Left subtemporal decompression. Usual incision and bone removed; no complications. Dura was very tense (exceedingly so—the highest I have yet seen). Upon incising the dura, lacerated cerebral tissue and dark blood clots welled out of opening; I attempted to tap the left ventricle, but brain tissue oozed out of needle showing the great intracerebral pressure. Usual closure with drains. Patient in fair condition.

P.O. Patient never regained consciousness. Temperature rose to 104° and pulse 140, and the respirations became more labored and shallow; the emphysema of the chest and neck extended down the entire right arm. Marked abdominal distention. Edema of the lungs now occurred, and patient died at 10.30 P. M., November 11, 1913, 78 hours after admission. No autopsy obtained.

Remarks: I doubt very much whether any treatment could have saved this patient. The intracranial pressure was so exceedingly high that the decompressions were insufficient to relieve it, and they merely prolonged life for a few hours. Besides, the other injuries of the body, especially of the chest, were very significant. I believe the operations gave this patient the only chance she had to recover, and they failed in this case.

CASES OF SEVERE FRACTURES OF THE SKULL; MEDULLARY EDEMA; NO OPERATION; AUTOPSY

CASE 1

———, Lorenzo. 40 years. Range maker.

Diagnosis: Fracture of vault and base. Medullary edema. No operation. Died.

Admitted Polyclinic Hospital, April 7, 1914, 8 A. M. Discharged, dead, April 7, 1914, 3 P. M., 7 hours after admission.

F.H. Negative.

P.H. Negative.

P.I. Patient was found lying upon sidewalk at 7.30 A. M. Unconscious. Ambulance.

P.E. T. 102.4. P. 150. R. 32. B.P. 112. Moribund. Well-developed, robust man. Alcoholic. Small hematoma over left occipital region; bleeding from nose. Pupils dilated, but equal; do not react to light. Fundi: Blurring of entire nasal halves of disks; dilated retinal veins. Breathing irregular, but not Cheyne-Stokes. Occasional twitchings of both arms. All reflexes, except corneal, abolished. Pulse 150, weak and thready. Loud systolic murmur over apex. Lumbar puncture: Very bloody cerebrospinal fluid, spurted a distance of 2 ft. Urine: Large trace of albumin; hyaline and granular casts; slight trace sugar. *One hour after admission,* fundi both showed "choked disks," left being more marked than right; veins were dilated and tortuous. Hematoma over left occipital region gradually became larger and larger until finally, before death, it infiltrated whole posterior part of scalp, coming down over left face anteriorly. *Two hours after admission,* double Babinski appeared. Breathing stertorous and irregular, but not typical Cheyne-Stokes. It was only by the most active stimulation the man lived until 3 P. M. After 11 A. M., pulse was so rapid that it could not be counted. After 1.30 P. M. the pulse could not be felt at wrist. Edema of lungs very evident, and patient died at 3 P. M., 7 hours after admission.

Autopsy (Dr. O. H. Schultze): Scalp: Very large and extensive hematoma over entire posterior portion, extending forward to both external orbital processes; not *in cutis,* i. e. subpericranial. Old scar in left frontal region with depression of the outer table. Several contusions over left occipital area—hemorrhage in cutis, i. e. area of contact. Skull is of odd shape, very nearly round; very thick bone. **Fractures:** Main fracture extended transversely around the entire posterior portion of skull into both mastoid bones. Another slight line of fracture in median line beginning at the occipital prominence and extending anteriorly along attachment of the superior longitudinal sinus to the vertex, about 4 in. Dura intact. No epidural clot. Many subdural clots, especially over temporosphenoidal lobes; extensive lacerations of both temporosphenoidal lobes, especially right. Clots over both frontal lobes. No hemorrhage under tentorium. No hemorrhage at base around pons or medulla. Hemorrhage in left middle ear, though the tympanic membrane intact; periosteum torn over petrous portion of left temporal bone.

Remarks: An operation was not advised in this case, as the patient was moribund upon admission. Medullary edema had already occurred, as shown by the high pulse rate and its shallow thready character, and the low blood-pressure. An operation at this late period would merely hasten the exitus, being but an added shock. Such cases are doomed—operation or no operation. The presence of blood in the left middle ear and yet the tympanic membrane remaining intact is a fairly frequent observation in cases of fracture of the skull. Unless a paracentesis

is performed to allow the blood to escape (naturally under the strictest asepsis), the hearing of that ear will become impaired.

CASE 2

——, James. 55 years. Horseshoer.

Diagnosis: Fracture of vault and base. No operation. Autopsy.

Admitted Polyclinic Hospital, April 2, 1914, 2 A. M.

Discharged, dead, April 2, 1914, 11 A. M., 9 hours after admission.

F.H. Negative.

P.H. Negative.

P.I. Patient was found lying upon sidewalk; considered alcoholic. Unconscious. Ambulance.

P.E. T. 102.6. P. 90. R. 28. B.P. 140. Unconscious. Pupils: Right dilated, left contracted. Fundi: Retinal veins dilated; nasal halves of disks blurred. Slight spasticity of left arm and leg; no Babinski. Breathing heavy but not Cheyne-Stokes.

6 A. M., 4 hours after admission: Condition same. Breathing very light and irregular. Pupils both dilated. T. 103. P. 60. R. 16. B.P. 140. (The operation should have been performed at this time, as pulse was descending, not ascending.)

9 A. M. Unconscious. Breathing light and irregular. Fundi: Nasal halves blurred. Spasticity left arm and leg; Babinski still present. T. 103.6. P. 100. R. 24. B.P. 130. (Pulse rate ascending.)

10 A. M. Patient taken to operating room; an operation could not be performed as patient stopped breathing and it was only with considerable difficulty that artificial respiration kept patient alive. Pulse 110; respiration shallow and irregular; B. P. 100. Patient became rapidly worse and worse, pulse ascending to 150, and had frequently to be resuscitated. Patient finally died at 10.30 A. M., before the operation could be attempted.

Autopsy (Dr. O. H. Schultze): Scalp: Small hematoma of contact over left occipital region. Large hematoma evenly distributed over entire right temporoparietal area, reflected over temporal fascia (this was due to the fracture as it was not in the cutis, but below the pericranium). Line of fracture began at the point of contact just below left parietal crest and extended around skull posteriorly through the posterior attachment of temporal muscle and into the inferior temporal ridge anteriorly; here it bifurcated into 2 small branches, each 1 in. long. Small hemorrhage beneath the torn periosteum of right orbital plate, but orbital bone itself intact (i. e. a subconjunctival hemorrhage is possible without a fracture of the orbital bones). Middle ears negative. No epidural clot. Dura was intact all the way around, even under the line of fracture. Brain: Very large subdural clot over entire right cerebrum; clot of 12 oz. Clots and cortical laceration over both subfrontal regions and tips of temporosphenoidal lobes, also prefrontal; all more marked on right side. Extensive laceration of right temporal lobe. No hemorrhage under tentorium. No clots at base around the pons or medulla.

Remarks. This case illustrates the necessity of early operation in severe cases of fracture of the skull, unless the patient is in much shock; an early operation would, I believe, have saved the life of this patient. In any case, with a pulse below 90, and especially if the pulse is descending, then the operation should be performed; but if the pulse is 110 or more, and especially if the pulse rate is ascending, then operation is but an added shock and will, in my opinion, merely hasten the exitus.

Case 8

———, Agnes. 31 years. Housewife.

Diagnosis: Fracture of base of skull. No operation. Autopsy.

Admitted Polyclinic Hospital, May 28, 1914.

F.H. Negative.

P.H. Negative.

P.I. While hanging out clothes, patient fell from fire escape, 12 ft. to stone sidewalk below. Unconscious. Ambulance.

P.E. T. 97.6. P. 82. R. 20. B.P. 135. Semi-conscious. No bleeding from ears or nose. Pupils equal and react normally. Knee-jerks active and equal. No Babinski. Abdominal reflexes present and equal. Fundi negative. Lacerated scalp over left occipital bone—3 in. in length. Treatment, expectant palliative; observation.

May 29th. T. 101.2. P. 90. R. 22. B.P. 140. Headache and backache. Physical examination same as at preceding examination. Impairment of hearing of left ear—middle ear lesion. Weber's test: Sound always referred to left ear. Rinne's test: Bone conduction greater than air conduction. Otoscopic examination—negative. Lumbar puncture—negative.

May 31st. T. 99.2. P. 84. R. 20. B.P. 135. No complaints. Patient seems to be improving rapidly.

June 1st. T. 98.2. P. 74. R. 18. B.P. 130. Rather restless night.

June 2nd. T. 99. P. 76. R. 18. B.P. 135. Headache, not severe.

June 3rd. 10 P. M. T. 100.2. P. 80. R. 20. B.P. 135. Severe headache; very restless. Nauseated for several hours; finally vomited once. Physical examination negative. Fundi: Some fulness of retinal veins; no edema of optic disks.

June 4th. Patient was restless at 1 A. M. and 1/6 gr. morphin administered hypodermically. At 5 A. M., when nurse tried to awaken the patient, the latter could not answer; unconscious. Fundi same as at preceding examination. T. 103.8. P. 120. R. 20. B.P. 140. No convulsions. No ocular paralyses. Some stiffness of neck. No Kernig. Reflexes active but equal; no Babinski. Patient rapidly became worse; pulse rose to 184, and respiration became irregular and then ceased; artificial respiration and pulmotor continued life until 9.30 A. M.

Autopsy (Dr. O. H. Schultze): Laceration over left occipital area about 3 in. in length. Circumscribed hematoma about 4 in. in diameter, over right frontal bone. Entire left hemisphere and part of superior portion of right hemisphere covered by thin creamy plastic exudate; right hemisphere normal except for slight area of exudate upon its upper portion. Left hemisphere pale, convolutions poorly outlined. Cortical lacerations and slight hemorrhage over right subfrontal and tip of right temporosphenoidal lobes. At the base was a collection of thick, creamy exudate (pus). Cortical laceration like a furrow in left lobe of cerebellum posteriorly, corresponding in part to point of contact. Small extradural clot in posterior fossa. Fracture line—bursting type—extended about ½ in. below point of contact vertically downward alongside of foramen magnum ½ in. to left—through posterior fossa—reaching its termination at base of lateral sinus. Another line of fracture in same general direction as preceding and looking like a continuation—but apparently no connection—across petrous portion of left temporal bone in its inner third, through the middle ear; it was 1 in. long. Infection probably developed from here. Subperiosteal hemorrhages beneath both orbital plates.

Remarks. This case is most instructive. A bump on the head, unconscious for several minutes and then brought to the hospital; consciousness quickly regained, no physical signs of a fracture of the skull and an apparently good recovery until 4 days later, when severe headaches began, followed by nausea and vomiting, and within 24 hours the patient is dead. The autopsy discloses a purulent meningitis, not only of the base but of the cortex; the entrance of infection was most probably through the fracture of the left middle ear, as the cortex underlying the occipital fracture was normal.

If this case had recovered, the diagnosis would have been a "possible fracture of the skull," or even a "severe concussion with laceration of the scalp"; I am confident that many fractures are thus diagnosed; in these cases, careful X-ray pictures at different angles may facilitate correct diagnosis. I cannot explain the absence of marked signs of intracranial pressure—especially upon the fundus of the eye. A lumbar puncture later would possibly have been of great value.

Case of Cortical Hemorrhage Following "Bump on Head"; No Cranial Operation; Death; Autopsy

———, David. $4\frac{1}{2}$ years.

Diagnosis: Hemorrhage upon cortex following "bump of head." No cranial operation. Death. Autopsy. Referred by Dr. B. Van D. Hedges, Plainfield, New Jersey.

F.H. Negative. Two brothers and one sister well and strong.

P.H. Negative. Always well and strong; no diseases of childhood.

P.I. On February 17, 1914, while playing with his brothers, patient fell upon the ground, striking his head; apparently no loss of consciousness. No bleeding from ears or nose. Upon rising, patient seemed rather drowsy; he was seated in a chair, and $\frac{1}{2}$ hour later, it was noticed that patient could not move his right leg and within another hour, the right arm became weak and then paralyzed; no paralysis of right side of face; no aphasia, though a definite slurring of words. No fever; pulse and respiration were normal, no nausea or vomiting. Within 6 hours, the paralysis became less marked, first in the arm and then in the leg, so that, within 36 hours, the child was apparently normal. *Three weeks later*, March 6, 1914, after being in as good health apparently as before the "bump" on the head, the parents observed that the child was limping on the right leg, and within 4 hours the right leg was paralyzed and the right arm was much weaker than the left arm; no paralysis of face. Some drowsiness. No general convulsions, but the fingers of the right hand twitched infrequently. No nausea or vomiting; appetite good; bowels regular daily.

March 7, 1914. Patient examined in consultation with Dr. Hedges and Dr. Robert Abbe. Physical examination. T. 99.4. P. 88. R. 24. Well-nourished child; perfectly conscious. The paralysis had already lessened so that the right arm was almost normal, but the right leg was definitely weaker than the left leg; no facial paralysis. We were unable to induce the child to talk, although the parents said he had been talking normally before our examination. No disturbance of sensation. Reflexes: Right greater than left; right Babinski. No clonus. Right abdominal reflexes depressed. Pupils: Left smaller than right; normal reaction. No ocular paralyses other than possibly a slight weakness of the left external rectus. No nystagmus. Fundi: Moderate dilatation of the retinal veins; definite blurring of the nasal margins of the optic disks, left possibly greater than right. Heart and lungs negative. Liver extended $\frac{1}{2}$ in. below costal margin and not considered abnormal for a child of $4\frac{1}{2}$ years of age. Spleen just palpable. No abdominal pain or tenderness. At that time, the tentative diagnosis was a small cortical hemorrhage, a possible tuberculoma or tuberculous meningitis of mild severity. The blood and cerebrospinal fluid by lumbar puncture were advised, to obtain a Wassermann test and cell count; these were returned negative.

Within 36 hours after this second onset of paralysis, the child gradually became normal, and it remained in its normal good health until July 7, 1914, 4 months after the second attack of paralysis; the parents then observed that the child was not using the right side of its face, and upon examination at my office on July 11, 1914 (4 days later), I found an almost total right facial paralysis (central in origin), and a slight weakness of the right arm; the right leg was apparently normal. Some blurring of speech. No sensory disturbance. Reflexes: Right greater than left; a tendency to a right Babinski reflex. No clonus. Abdominal reflexes: Right less active than left. Fundi: Slight dilatation of the retinal veins, and the blurring along the nasal margins, especially of the left optic disk, still persists. No ocular paralysis. No nystagmus. Heart and lungs negative.

During the routine examination of the abdomen, however, a firm modular mass—the size of an orange—was palpable in the upper right hypochondrium; it was evidently in the liver, which extended down to the level of the umbilicus. There were no jaundice and apparently no digestive disturbances. The spleen and right kidney were just palpable; apparently normal.

The child was admitted to the Polyclinic Hospital on July 12, 1914; after the laboratory tests of the blood, cerebrospinal fluid, urine and stool, including the tuberculin and luetin tests had been made and were all negative, Dr. J. P. Grant made an exploratory incision through the right rectus muscle and removed a hard fibrous tumor, the size of a large fist, from the liver; the pathological report was a small round sarcoma. The child died 8 hours after operation.

An autopsy revealed not only sarcomatous masses in the liver, but also extensive involvement of the lymph nodes of the lesser and greater curvatures of the stomach and in the mediastinum; sarcomatous enlargement of the head of the pancreas and sarcomatous nodules in the right kidney; the adrenals were normal.

In the brain, however, was a bluish hemorrhagic clot—$\frac{1}{8}$ in. in thickness—in the pia-arachnoid, overlying the precentral area of the left motor cortex and extending forward into the left frontal lobe and from the longitudinal fissure downward almost to the left Sylvian fissure; the posterior portion of the third left frontal convolution was partially covered. Careful sectioning of the brain did not reveal any sarcomatous degeneration or any other lesion. The vault of the skull and also the base did not exhibit any sign of fracture.

Remarks. This case is most unusual. A "bump on the head," not worse than is frequently received by children, followed by paralysis, which improves only to return 3 weeks later; another rapid recovery and then a return of paralysis 4 months later. The appearance of a rapidly growing tumor in the liver, which proves to be a small round-celled sarcoma with many metastases, and yet the brain is not involved—only the cortical hemorrhage of the early "bump" being ascertained; the absence of a fracture of the base or vault in similar cases is not uncommon. The possibilities of diagnosis were many.

TECHNIC OF THE OPERATION

In cases of fracture of the base of the skull, showing definite signs of increased intracranial pressure, as revealed by an ophthalmoscopic examination (as outlined above), when the patient is not in a severe condition of shock, the following subtemporal decompression is performed. Unless there are definite signs of greater involvement of the left hemisphere, the operation is always performed on the right side, that is, the operation is always a right subtemporal decompression unless there are localized signs of pressure over the left cerebral cortex. The reason for selecting the right side for the operation is to avoid the motor speech area, situated in the third left frontal convolution in right-handed patients; also, the left cerebral cortex is apparently more specialized for function than the right cerebral cortex, and it is wiser to perform the operation on the less important side of the brain. Naturally, in left-handed patients, the operation is preferably performed on the left side, as in them the right cerebral cortex is the more important, their motor speech area being in the third right frontal convolution.

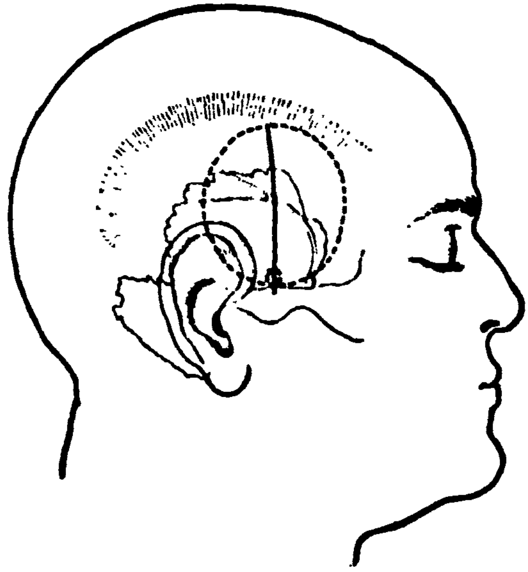

FIG. 3. · VERTICAL INCISION EXTENDING FROM PARIETAL CREST DOWN TO ZYGOMA. The dotted line indicates the area of bone removed.

In preparing the patient for the operation, a laxative should be given the preceding night and a soapsuds enema administered before the operation. The head may also be closely shaved the night before the operation, and a green soap poultice applied. In emergency cases, however, the head may be shaved just before operation; it is of the greatest importance that the head, or at least the operative site, should be most carefully shaved, as the danger of infection from hair and slight shaving cuts is to be feared. The entire side of the head is now thoroughly scrubbed with green soap, then with 70 per cent. alcohol and finally with 1:3,000 solution of bichlorid of mercury. A solution of iodin is not used, as it tends to irritate the scalp and thus render possible a secondary infection. The above method is simple and effective, an infection of the skin being a very rare occurrence. The head is now draped with towels, which are clipped to the scalp to avoid any displacement and possible infection.

The incision extends through the scalp down to the temporal fascia, from a point ½ in. anterior to the external auditory meatus and overlying the zygoma, vertically upward to the middle portion of the parietal crest, a distance of 3 to 3½ in. Hemostats are now applied to the temporal artery and its branches, which have been compressed manually. The temporal fascia is now incised in the same manner as the scalp, and the fibers of the underlying temporal muscle are separated longitudinally, that is, the muscle fibers are not cut, as this would necessarily not only weaken the muscle, but increase the amount of blood lost.

The temporal muscle is separated from the underlying squamous bone, great care being taken to preserve the attachment of the muscle to its parietal crest, in order that the muscle may not be weakened. (This is not only most important in tumor cases, but also in severe cases of fracture of the skull, where an increasing intracranial pressure may cause a distinct hernia, unless the temporal muscle is firmly attached to its parietal crest.) With the temporal muscle thus split and so retracted to expose widely the underlying squamous portion of the temporal bone, the Doyen perforator and burr are now

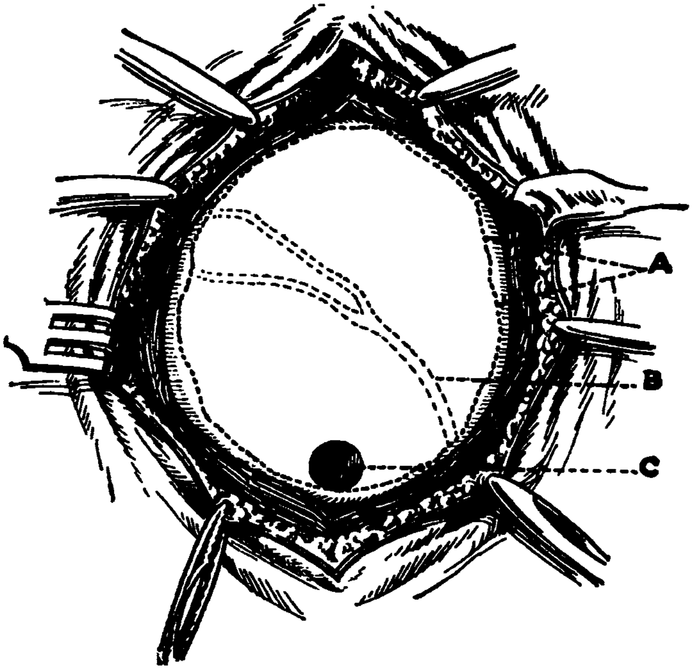

Fig. 4.—Area of Bone Exposed by Retracting Overlying Temporal Muscle. The dotted line (A) indicates the extent of bone to be removed; the dotted lines (B) show the course of the underlying middle meningeal artery. The skull is opened in the lowest part of the squamous bone exposed (C), that is, the thinnest part of the vault.

used to make an opening in the skull at the lowest (and therefore, anatomically, the thinnest) part of the squamous bone; in this manner, the middle meningeal artery is easily avoided. The use of the trephine in this region is doubly dangerous—the great danger being of cutting the middle meningeal artery and also the dura itself, as the thickness of the bone varies considerably. The Hudson drill does not always stop upon reaching the dura, with disastrous results; on the other hand, the operator knows that the Doyen perforator will not stop automatically upon reaching the dura and, therefore, he always uses great care, whereas he is apt to depend upon the Hudson instrument to stop (as it usually does) and so possibly becomes careless. I have known personally of two deaths due to failure of the instrument to stop. Electric-motor instruments in decompression operations are of little value; even in cranial operations of greater magnitude, they are, in my opinion, neither time-saving nor energy-saving, while there is the added danger of damage to the dura and the underlying cortex. Especially is this true in the use of the circular saw, as the thickness of

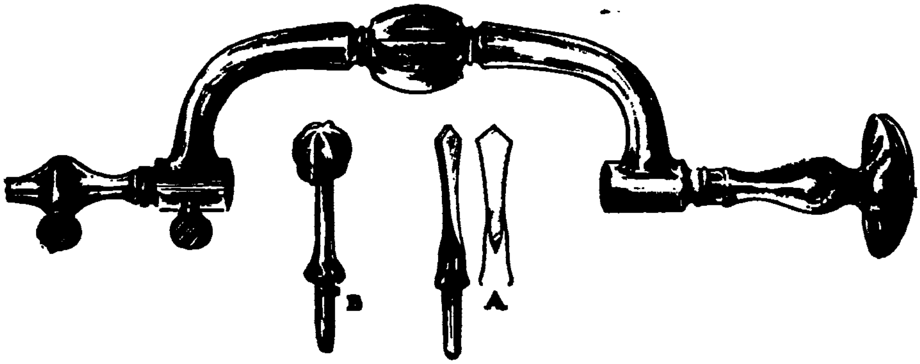

FIG. 5.—THE DOYEN INSTRUMENT WITH ITS PERFORATOR (A) AND ITS BURR (B).

the skull varies rapidly, at times 1 cm. within a distance of 1 in.; it has few, if any, advantages, and many dangers in its general adoption. Besides, the instrument is very liable to get out of order and, unless the motor and its equipment are thoroughly understood by the operator, much time may be lost. I have frequently seen operations delayed many minutes by this cause.

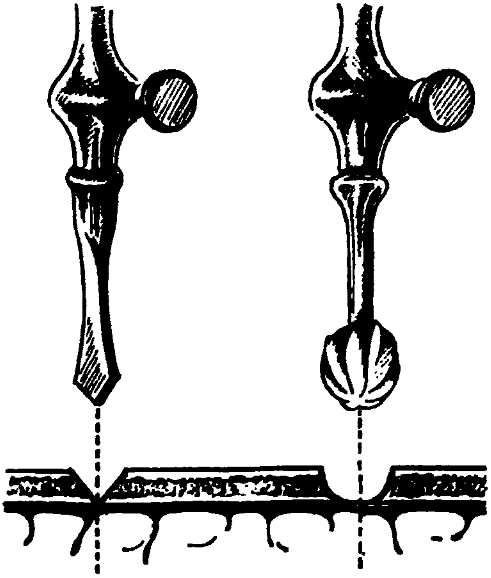

FIG. 6.—DIAGRAMMATIC CROSS-SECTIONS OF VAULT, SHOWING THE SAFE METHOD OF OPENING THE SKULL. A pin-point opening is made by the Doyen perforator and then enlarged by the Doyen burr so that rongeurs can be used. In this manner, the dura and its underlying cortex are never injured, and the middle meningeal artery can be avoided.

The pin-point opening in the bone made by the Doyen perforator and burr is now enlarged first by small rongeurs and then by larger ones; the dura should always be carefully separated from the overlying bone by the dural separator, for fear of its being torn by the rongeurs. It is advisable to use rongeurs having one of the blades flat and thin, so that it can easily be inserted between the dura and the bone and thus avoid the possible tearing of the dura. In this manner, an area of bone underlying the temporal muscle is removed to a diameter of 3 in. extending from the parietal crest down to the zygoma, and from the upper mastoid cells forward to the greater wing of the sphenoid bone (that is, the opening in the bone should be as large as possible under the temporal muscle), extending downward to the base of the skull, in order that the middle fossa may be properly drained, and upward to the attachment of the temporal muscle to the parietal crest and not beyond. As the middle meningeal artery usually channels the bone at the anterior part of the opening, it is wise to have some pellets of bone-wax to plug the vessels if encountered, and also to control any oozing from the bony margins of the opening. (The composition of the wax as formulated by Dr. Norman Sharpe is as follows: White wax, 7¼ parts; almond

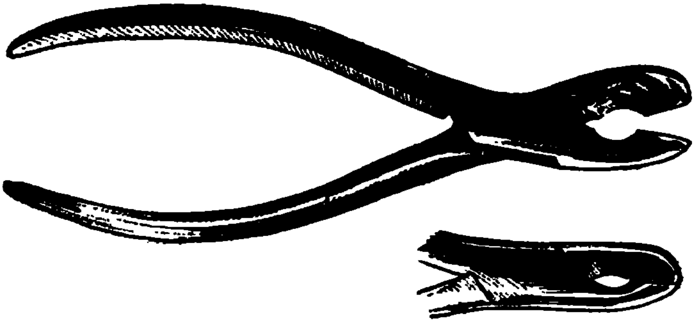

FIG. 7.—BONE RONGEURS HAVING A THIN LOWER BLADE WHICH CAN BE INSERTED BETWEEN THE BONE AND DURA WITHOUT TEARING THE DURA.

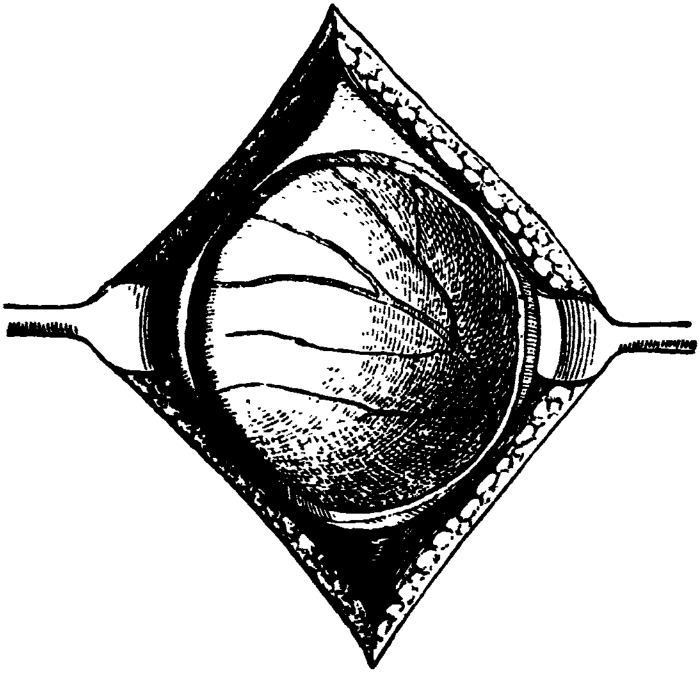

FIG. 8.—AREA OF BONE REMOVED, EXPOSING UNDERLYING DURA AND BRANCHES OF MIDDLE MENINGEAL ARTERY.

oil, 1½ parts; salicylic acid, 1¼ parts. Keep in 5 per cent. sol. carbolic acid. It can be readily sterilized by boiling before the operation and then allowed to harden by cooling. It is easily rubbed into bony surfaces and is most effective in controlling oozing; I should think it would be excellent for operations upon bone other than the skull.)

If an extradural hemorrhage is present (and this is its most frequent site due to a tear in the middle meningeal artery), then the clot can be easily removed.

FIG. 9.—DURAL HOOK FOR ELEVATING DURA BEFORE INCISING IT. In this manner the underlying cerebral cortex is never injured.

The dura is now opened by incising its outer layer and then inserting a small hook into it, thereby elevating its inner layer from the underlying cortex, and then incising it upon a grooved director for a distance of 1 in.; in this manner, there is little danger of damage to the cortex. A spoon-shaped spatula is now inserted between the dura and the cortex, and the dura is incised in a crucial and stellate manner—in this way allowing the cortex to bulge outward into the decompression opening. Subdural hemorrhages may also be removed—most safely by allowing warm saline solution from a cotton sponge to trickle upon the cortex.

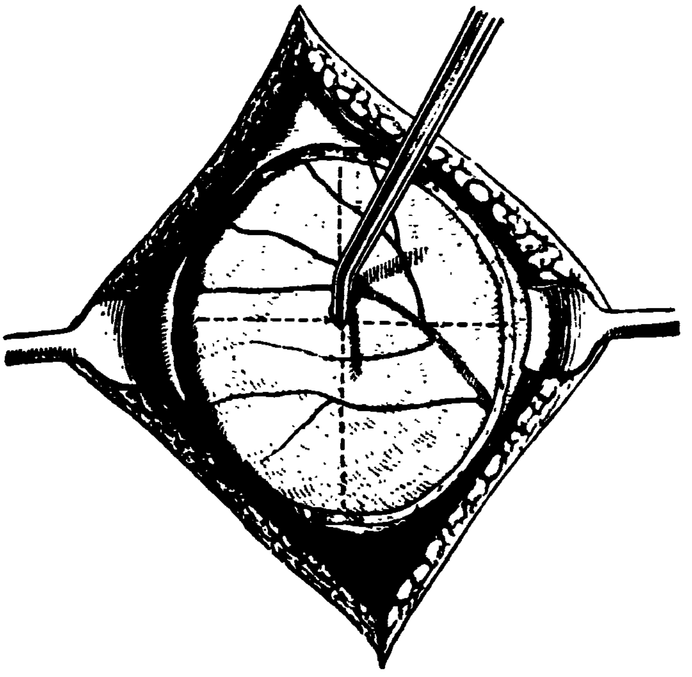

FIG. 10.—DURA INCISED ON A GROOVED DIRECTOR IN EITHER A CRUCIAL OR STELLATE MANNER. The branches of the middle meningeal artery are ligated by the silver clips.

In edematous, swollen brains the cerebrospinal fluid may be seen to ooze through the arachnoid from the subarachnoid space into the subdural space; it appears like beads of perspiration upon the forehead—the so-called pia-arachnoid "sweating." In this manner, very tense brains are rapidly relieved of their pressure, and I have repeatedly observed unconscious patients (an anesthetic not being necessary) show signs of returning consciousness at this stage of the operation, so that an anesthetic had to be administered; in other cases consciousness returns less rapidly—not until the end of the operation or later, so that the entire operation may be performed without an anesthetic. In many cases, this "sweating" may be increased by puncturing the arachnoid in various places with the point of a needle; it should be remembered, however, that a too rapid escape of cerebrospinal fluid may precipitate a condition of shock and collapse, probably due to an interference with the blood supply of the basal ganglia, resulting in a very high temperature—over 106° within three hours after operation. To prevent a large, sudden loss of cerebrospinal fluid, the head should be elevated just before the dura is incised. (Dr. Charles S. Hunt has observed in administering ether to these cases, that, unless the patient is deeply under the anesthetic when the dura is opened, there is great danger of the patient becoming semi-conscious, coughing, struggling, etc., showing the immediate relief afforded by lowering the

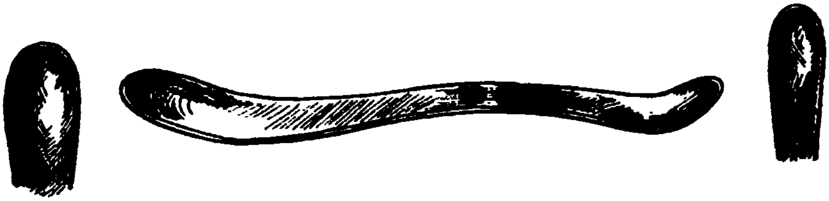

FIG. 11.—SPOON-SPATULA. A very useful instrument for protecting the underlying cortex when cutting the dura; of much value in exploring the adjacent cortex beneath the bony margins of the decompression opening.

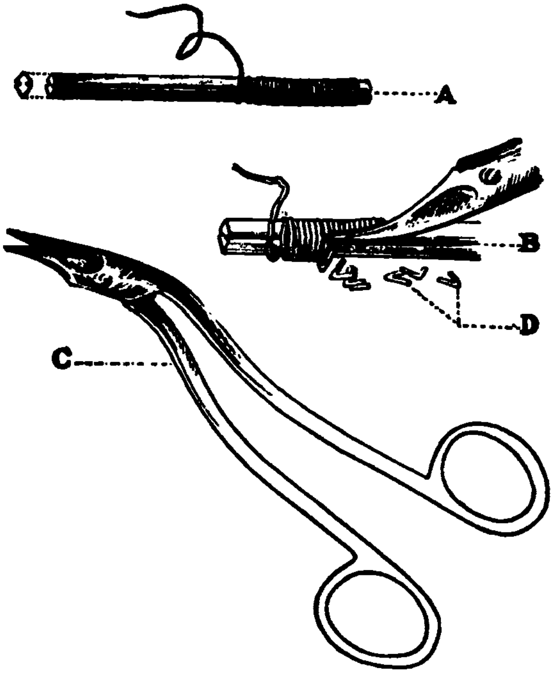

FIG. 12.—METHOD OF MAKING SILVER CLIPS FOR LIGATION OF DURAL VESSELS. German silver wire (No. 24) is wrapped snugly around the rectangular grooved bar (A), and then cut in the groove on each side (B) by the wire-cutting scissors (C). The V-shaped silver clips (D) are thus easily made.

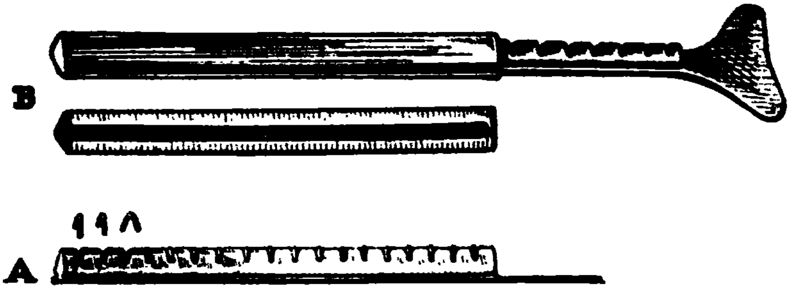

FIG. 13.—SILVER CLIPS PLACED IN GROOVES OF HOLDER (A), INSERTED INTO ITS COVER (B), STERILIZED, THEN READY TO BE USED.

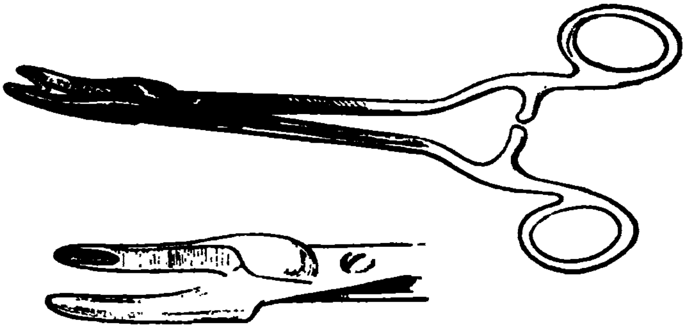

FIG. 14.—GROOVED FORCEPS FOR HOLDING SILVER CLIPS. By closing the forceps, the silver clip compresses the dural vessel so that the dura may be incised rapidly and yet no bleeding occurs; no ligatures are necessary.

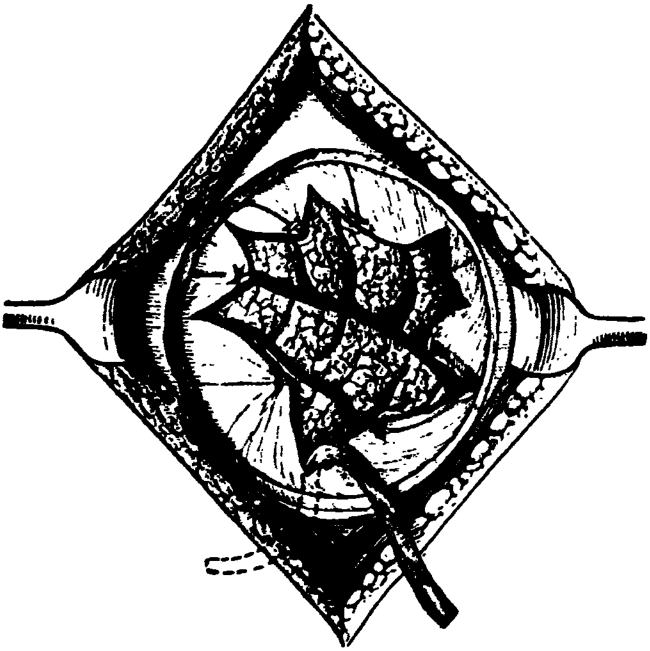

FIG. 15.—DURA OPENED IN A STELLATE MANNER, EXPOSING UNDERLYING CEREBRAL CORTEX AND ITS VESSELS. A rubber tissue drain inserted in the middle fossa beneath the temporosphenoidal lobe.

intracranial pressure; this is to be avoided, if possible, while the cortex is exposed, not only for fear the brain may be damaged, but also to lessen the amount of venous oozing; any straining or coughing at this stage of the operation is a serious complication, so that a "smooth" anesthesia is most essential.)

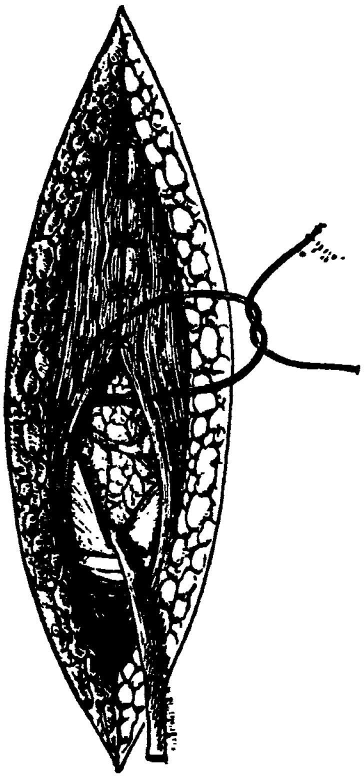

FIG. 16.—CLOSURE. SUTURING DEEPER LAYERS OF TEMPORAL MUSCLE OVER DURAL OPENING. The dura is never sutured.

Most valuable instruments to be used in ligating the dural vessels are the V-shaped silver clips; 2 of these small clips are squeezed upon the meningeal branches by means of a holder and then the vessel may be cut between them without any loss of blood at all. Not only is this method faster and easier than the method of ligation by needle and silk, but it entails no danger, whereas there is always the risk of puncturing the underlying cortical vessels with the needle, and in this manner causing much damage. These silver clips are left upon the vessels. Apparently they are not irritating to the surrounding tissues as no after-effects are observed clinically and, in 3 cases of cerebral tumor dying within a period of 2 years following the operation, the clips remained the same as when applied, there being no reactive connective-tissue collection about them.

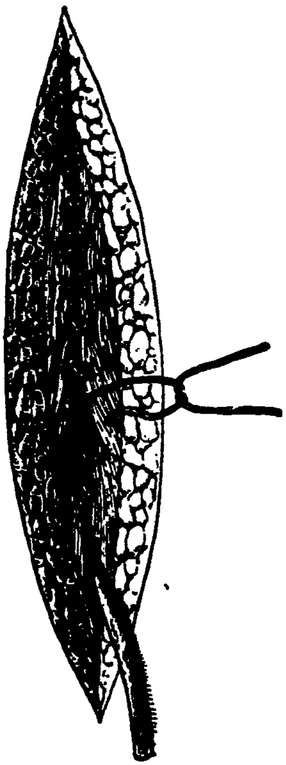

FIG. 17.—SUTURING UPPER LAYERS OF TEMPORAL MUSCLE.

Owing to the gradual loss of cerebrospinal fluid, the tense, edematous brain becomes less swollen and bulky, so that it may no longer tend to protrude through the decompression opening. In order to allow a continuous escape of any excess fluid and blood, a rubber tissue drain, 1 in. in length, 1/4 in. in width and 1/16 in. in thickness (about 6 layers), is inserted at the lower angle of the manner, the middle fossa of the base of the skull is well drained of free blood incision under the dura downward beneath the temporosphenoidal lobe; in this and cerebrospinal fluid. In my opinion, this drainage is most important in continuing to relieve the intracranial pressure and thereby to offset the pressure of intracranial hemorrhage and edema wherever present, though especially in supratentorial lesions.

All bleeding points having been stopped, the closure of the incision is now begun by suturing the lowermost layers of the temporal muscle with interrupted fine black silk, and then the entire muscle, in at least 3 layers, in the same manner. Naturally, the dural incisions are not sutured together; not only would it be impossible to accomplish in most cases, on account of the cerebral tension, but, if successful, it would prevent a decompression, because the dura in adults is inelastic, and, therefore, a relief of the intracranial pressure, except momentarily following the dural opening, would not occur.

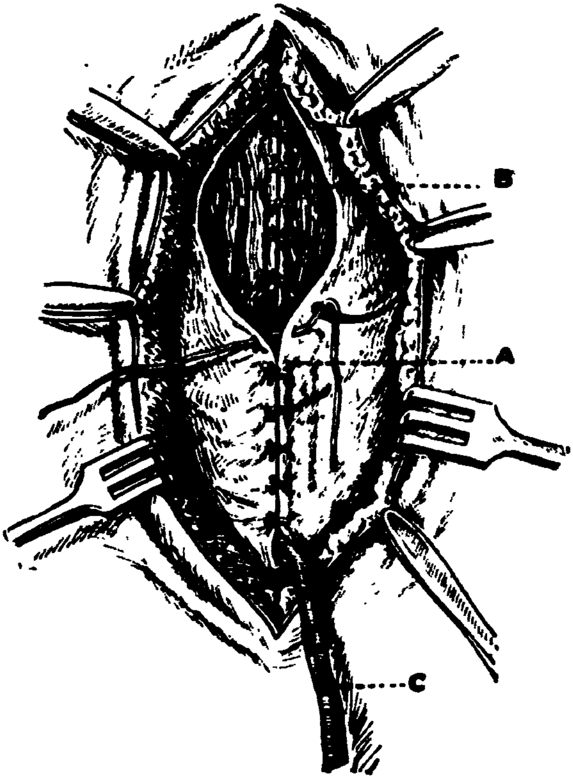

Fig. 18.—Temporal Fascia (A) Sutured Over Underlying Temporal Muscle (B). This makes a firm closure; a hernia cerebri is not possible. Drain (C).

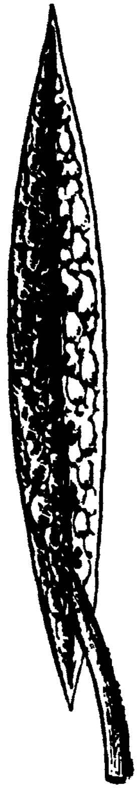

Fig. 19.—Strong Temporal Fascia Sutured. A subcutaneous suture of interrupted fine black silk.

The danger of adhesions forming between the muscle and the underlying cerebral cortex is clinically not to be feared; in 3 cases of irremovable cerebral tumor, upon whom a subtemporal decompression operation had been performed to offset the pressure effects and thus preserve the vision, post-mortem examinations of 31, 22 and 9 months respectively following the operation, revealed the formation of a new dura and no adhesions; in the case dying 31 months after the operation, the new dura could not be distinguished from the surrounding dura.

The temporal fascia is united with interrupted fine black silk; at times a close approximation of its edges is difficult, owing to its retraction and inelasticity and the cerebral tension. Subcutaneous sutures of fine black silk make the application of ligatures unnecessary; the temporal artery, however, may be ligated when it cannot be caught in one of the subcutaneous sutures. The skin is sutured with interrupted black silk, and the usual gauze dressing is applied; a small cotton pad should always be placed behind the ear—otherwise, the lobe of the ear may be compressed against the skull by the head bandage, causing the patient to complain more of this pain than of the pain at the operative site. Singularly enough, the postoperative pain is slight.

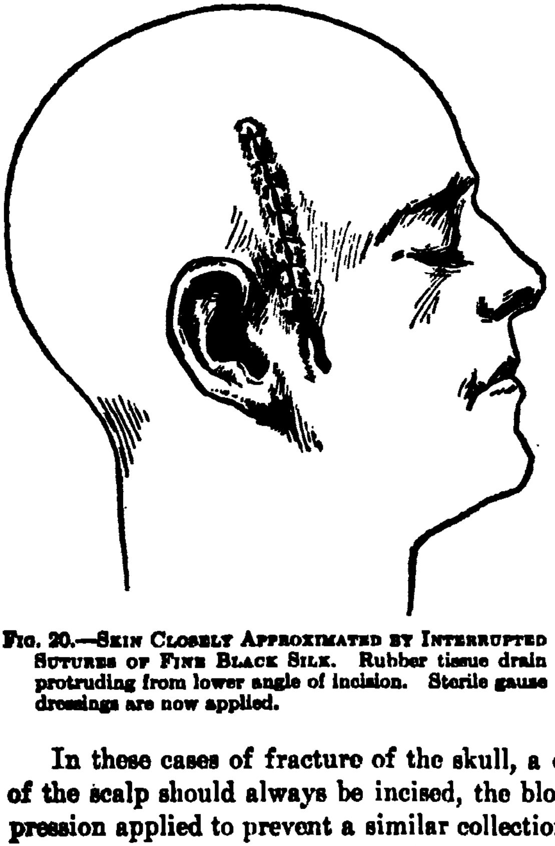

FIG. 20.—SKIN CLOSELY APPROXIMATED BY INTERRUPTED SUTURES OF FINE BLACK SILK. Rubber tissue drain protruding from lower angle of incision. Sterile gauze dressings are now applied.

In these cases of fracture of the skull, a definite hematoma of any portion of the scalp should always be incised, the blood expressed, and firm local compression applied to prevent a similar collection of blood; otherwise, these hematomata become infected only too frequently, and the patient dies from a resulting meningitis within a fortnight.

POSTOPERATIVE TREATMENT

The routine treatment is as follows:

1. Elevate the head and shoulders with pillows, 35 to 40 degrees.

2. Water by mouth as soon as nausea ceases.

3. 400 c. c. hot normal saline per rectum immediately, and repeated every 4 hours for 24 to 36 hours. If the patient shows any signs of operative shock, then 400 c. c. of hot black coffee per rectum is administered after the operation, and this is repeated 4 hours later, if deemed necessary. Urotropin, gr. 5 to 10, may be given in the rectal saline every 4 hours; it is believed to inhibit the growth of bacteria in the cerebrospinal fluid, and in this way, possible

infection and resulting meningitis are avoided. Its real efficacy is doubtful; it can, however, do no harm, and it may do some good.

4. T. P. and R. every hour for 12 hours, and then every 2 hours.

5. Morphia, gr. 1/8 (hypo.), for restlessness, and repeat after 1 hour, if necessary. Naturally, the room should be cool and darkened, quietness being enforced. On the day following the operation, liquids, except milk, may be given.

On the second day postoperative, the first dressing is made; the drain is removed, allowing clear cerebrospinal fluid to trickle out; the drainage of bloody cerebrospinal fluid and blood itself in these cases, during the first 24 hours after operation, may be profuse, sufficient to soak through the dressings. At least one-third of the skin sutures may be removed.

All liquids may now be given; and, on the fourth day postoperative, soft diet.

On the fifth day postoperative, the second dressing is made; all skin sutures are removed, and the patient is placed upon a light diet. The average duration of hospital residence is 10 to 14 days.

CHOICE OF OPERATION

The osteoplastic "flap" operation should never be performed for cases of fracture of the skull, unless there is a large depressed area of the vault or there are unmistakable signs of a hemorrhagic clot over either superior motor area. Not only is it a much more dangerous and prolonged operation than the simple decompression, as described above, but it necessitates the resuturing of the dura beneath the bone flap—a most difficult proceeding in most cases, as the intracranial tension is high, owing to the edematous, swollen condition of the brain; besides, even if the dura were not sutured, the replacement of the bone flap prevents a real decompression. Frequently the clot is not to be found over the motor area of the cortex (even when the signs are most positive), so that in these cases the operative site would be over a most important area of the cortex and not even a relief of intracranial tension would be obtained; besides, there is some danger of producing a motor paralysis by the underlying motor cells of the cortex being pressed upward against the bony edges of the "flap" operation. As the decompression operation exposes the lower portion of the motor area, it can be readily ascertained by means of a spoon-shaped spatula whether a clot exists over a higher portion of the motor tract. However, it is not at all necessary to remove all the small clots lying upon the cortex, although naturally, if this can be done safely, so much the better; but it is essential to offset the general pressure effects of these clots and the accompanying edema of the brain, and this is the chief purpose of the decompression operation.

At autopsies upon fractures of the base, subdural and cortical clots are frequently found over the frontal lobes, the anterior portion (the "tip") of the temporosphenoidal lobes, and at the base. Naturally, to remove these clots themselves is impossible, but that is no reason why the general pressure effects of those clots should not be relieved; it is surprising how quickly the local pressure effects of a clot or a depressed area of bone will fade away when the resulting increased general pressure is relieved by a decompression operation. It is for this reason that a decompression operation is so effective in relieving the intracranial condition, especially when the local condition cannot, with certainty, be ascertained and removed.

Even in depressed fractures of the vault, unless larger than a silver dollar, it is advisable to make a small trephine opening at the edge of the depression and then remove the depressed area entirely with rongeurs. This is a simple procedure compared with the removal of the depressed area in one piece and much less dangerous. Besides, a bony defect not larger than a silver dollar is not to be feared, whereas the replacement of the depressed area of bone "upside down" is not always successful- -the bone necrosing at times, and thus making possible a number of complications.

Advantages of Subtemporal Decompression.—The advantages of the subtemporal decompression operation are many:

1. ITS SITUATION.- (a) The squamous portion of the temporal bone is the thinnest area of the vault of the skull; the subtemporal decompression is technically, therefore, less difficult and much less time-consuming; the average duration should not be longer than 1 hour. In cases associated with shock and profuse intracranial bleeding, the duration of the anesthesia and operation should be lessened as much as careful work and hemostasis will permit. No patient should ever be sacrificed for speed, as more shock results from rapid bleeding than from a moderately prolonged operation.

(b) It exposes the territory of the middle meningeal artery, a most frequent cause of intracranial hemorrhage in cases of fracture of the skull.

(c) It also permits excellent drainage of the middle fossa of the skull, the usual site of fractures of the base. As the squamous portion of the temporal bone is removed down to the base of the skull, the rubber tissue drain at the lower angle of the wound allows the free escape of blood and cerebrospinal fluid collecting in the middle fossa. Besides, drainage through the split temporal muscle does not weaken the scalp as it so frequently does if the operation is performed elsewhere on the skull.

(d) Then again, the sphenotemporal lobe is a common site for laceration of the brain in these cases, and thus effective exposure and drainage are possible.

(e) It exposes an area of the cortex (the temporal lobe) which is a comparatively silent area of the brain; that is, any operative damage that might result at the hands of a surgeon not trained in the special technic of operations upon the brain, or damage due to pressure of the nerve cells of the cortex protruding outward against the overlying tissues on the bony margin of the opening, would not be observable clinically, whereas if the motor area of the cortex is exposed, various combinations of paralyses are very liable to occur.

For this reason the decompression operation is comparatively a safe operation. I have removed the entire right temporosphenoidal lobe in a case of gliomatous degeneration, and there resulted no clinical impairment physically, mentally, or psychically.

2. THE PRESENCE OF THE TEMPORAL MUSCLE. The removal of the bone underlying the temporal muscle in no way weakens the skull, since its bony defect is well protected by the thick overlying temporal muscle, and a very high intracranial pressure is necessary to cause a marked bulging of this area. In cases of irremovable cerebral tumor, usually at the base of the brain, in which subtemporal decompressions have been performed to delay and even prevent a secondary optic atrophy with resulting blindness from the extreme increased intracranial pressure, it is surprising how tense the decompression area may become and yet a marked protrusion be avoided. If the decompression opening is not protected by this strong temporal muscle, then a most unsightly deformity of hernia and even a fungus are very possible in tumor cases, and such results are common if a bony defect is made elsewhere on the skull. In cases of fracture, however, the intracranial tension diminishes rapidly after the decompression is performed, so that within 2 to 4 weeks after the operation there is usually a depression at the operative site. In the subtemporal operation this "sinking in" is less marked, owing to the thickness of the overlying temporal muscle, whereas, if only the scalp covered it, the depression would be very evident. Not only does the temporal muscle prevent a hernial protrusion, but it also tends to protect the underlying cortex from later injury by accidents, unless a very sharp-pointed instrument is thrust through the opening.

As stated above, injury to the underlying temporal cortex is less to be feared than an injury to either higher parietal area. (In left subtemporal decompressions, the motor speech area is usually not exposed by the removal of its overlying bone.) In men, the hard rim of the derby hat, as well as the straw hat, tends to protect the subtemporal area. Bone plates, in my opinion, are unnecessary, and I believe they are the source of many complications; if infection and necrosis of the bone are avoided, then frequently the patient will complain of local pain due to the plate. In large bony defects of the parietal area, they may be serviceable, but I have never used them.

CONCLUSIONS

The treatment of fractures of the skull has been a most discouraging one; the mortality in the past has been 50 per cent. and more. The expectant palliative treatment has not been effective in the more severe cases, and the operative treatment has been delayed too long, until the patient was in a condition of medullary collapse. If the patient did recover after a period of weeks, then the danger of posttraumatic impairment was very great, being as high as 66 per cent.

It may be interesting to compare the above figures with the result of the treatment of cases of fracture of the skull admitted to the department of neurological surgery of the Polyclinic Hospital during the year ending June 1, 1914. Naturally, sufficient time has not yet elapsed to render these figures more valuable, especially in regard to the possible cases of posttraumatic impairment; however, since this impairment most frequently persists without cessation from the time of the injury, they may be accepted as approximately correct.

Total number of cases admitted—77.
Total number of deaths—27 (35.06 per cent.).

Eighteen of the 27 cases (66.66 per cent.) resulting in death were moribund upon admission to the hospital; that is, their condition was one of such extreme shock, due to the injuries of the head and of other parts of the body, that an operation could not be considered. These moribund cases died without an operation within the following time after admission to the hospital:

4 cases within a few minutes.
4 cases within 1 hour.
3 cases within 2 hours.
3 cases within 6 hours.
4 cases within 12 hours.

Total number of cases not operated upon—41.

Total number of cases dying without an operation—18 (43.9 per cent.).

Total number of non-operated cases recovering——23 (56.09 per cent.).

It must be remembered that the non-operated cases included the less severe fractures of the skull, fractures which did not produce marked signs of intracranial pressure, the so-called "latent" fractures. Three of these cases, however, did show a marked increase of the intracranial pressure, and a decompression operation was advised; the operation was refused. Two of them are now complaining of persistent headaches associated with vertigo; one has a "cloudiness" of vision with spells of depression; physical examinations reveal the signs of an old increase of intracranial pressure. The third patient is apparently as well as ever.

Total number of cases operated upon—36, i. e. 46.75 per cent. of those cases admitted with the diagnosis "fracture of the skull."

Total number of deaths following operation—9.

According to the above figures, 25 per cent. died after an operation; of these 9 cases, 5 were moribund at the time of operation, having a pulse rate of 120 and more, and I should not have operated upon them. It is always wiser to wait until the shock subsides, as any operative procedure upon these patients with a pulse rate of 110 or more is merely an additional shock. Autopsies upon 4 of these 5 patients showed subtentorial fractures with extensive lacerations of the brain and subdural hemorrhages. It is doubtful if they would have improved to the extent of permitting an operation later, and yet they illustrate the futility of operations in this extreme condition, a practice which I no longer follow. Two of the 9 deaths occurring at 9 and 16 days respectively following operation, were due to a meningitis caused by infected hematomata of the scalp and face; autopsies in both cases showed the operative area healed perfectly. The eighth case (of the nine) died on the twelfth day postoperative from pneumonia; the patient was seventy-five years of age. The ninth case died on the sixth day postoperative from a meningitis—probably due to a "slip" in the operative technic.

The cases which were operated upon were naturally the more severe ones—cases where it was believed that an operation would give the patient the only chance to recover; they were severe cases, also, on account of the danger of a medullary edema resulting from the high intracranial pressure. Besides the danger to the life of the patient, an operation was advised in the hope that no postoperative impairment—either physical or mental—would occur; in only 4 of these cases has there been as yet any impairment observed resulting from the laceration of the brain; a longer period of time, however, is necessary for data regarding this phase of the subject.

The operation itself is a simple one, requiring no special technic other than a due respect for the anatomy of the temporal region of the skull and the observance of a rigid asepsis; an expert anesthetist is most important.

It is after a consideration of the literature upon this subject and of the cases outlined above that I am of the opinion that the operative treatment for selected cases of fracture of the skull showing marked signs of intracranial pressure is far superior to the expectant palliative treatment, and that the operation most suitable for these cases is the subtemporal decompression.

OPERATIONS UPON THE BRAIN AND ITS MEMBRANES

CHAPTER X

OPERATIONS UPON THE BRAIN AND ITS MEMBRANES

CHARLES A. ELSBERG

CRANIOCEREBRAL TOPOGRAPHY

Up to within recent times, the surgery of the brain was that of the motor convolutions, and the need for complete knowledge of the relations of the surface of the brain to the skull had only practical importance in relation to the Rolandic area. The past few decades have brought about a great change, and now there is hardly a part of the brain, of its surface as well as of its interior, that has not surgical significance. Today the brain surgeon must thoroughly understand not only the relation of the various convolutions and fissures of the brain, of the nerves and other structures to the surface of the skull, but he must have a thorough knowledge of the relations of the ventricles to the surface.

To a certain extent, however, it must be acknowledged that the use of large bone flaps has made an exact craniocerebral topographical knowledge not absolutely indispensable in every case.

A description of the relations of the surface of the brain to the surface of the skull presupposes a knowledge of the lobes, convolutions and fissures of the brain, of the localization of functions, of the relation of the cerebral and cerebellar lobes to the inner surface of the skull. The reader must be referred for most of the details to works on anatomy and physiology; a general outline will be given in what follows:

The brain comprises the cerebrum, the midbrain, the cerebellum, the pons, and the medulla oblongata. The medulla is continuous with the spinal cord, the pons the continuation of the medulla; the cerebellum occupies the inferior occipital fossa and forms the posterior boundary of the fourth ventricle, being connected by bands of nerve tissue, the peduncles, with the midbrain above, the pons in the middle, and the medulla oblongata below. The midbrain is continued upward from the pons and mainly consists of the two peduncles of the cerebrum; the cerebrum comprises all of the remaining part of the brain. The two cerebral hemispheres, united by the corpus callosum, occupy the vault of the cranium, the anterior and middle fossæ, and the superior occipital fossæ. Within the cerebral hemispheres are the third and the lateral ventricles.

From the sides of the medulla arise the ninth, tenth, eleventh and twelfth cranial nerves. From the recess between the medulla and pons spring the seventh and eighth nerves, while from the ridge between the pons and medulla spring the sixth pair of nerves. The cerebellum consists of two lateral lobes joined above and below by the superior and inferior worm. The cerebellum occupies the posterior cranial fossa and is separated from the cerebrum by the tentorium. Its upper surface is in contact with the tentorium, its outer parts in close contact with the petrous portions of the temporal bone behind and external to the internal auditory meatus.

The midbrain is the short constricted part of the brain which unites the pons and cerebellum below with the cerebrum above, and contains within its substance the communication between the third and the fourth ventricles, the aqueduct of Sylvius. Tumors in this region cause an early compression of the aqueduct with marked internal hydrocephalus.

The cerebral hemispheres are separated by the longitudinal fissure in which lies the falx cerebri. As the latter extends only as deep as the corpus callosum, it follows that, below it, pressure can be transmitted from one side of the cerebrum to the other, while above the level of the free border of the falx, this part of the dura offers considerable resistance to pressure upon it. Hence, expanding lesions in the deeper parts of the brain are much more apt to give bilateral symptoms, while those situated more near the convexities of the hemispheres give for a long time unilateral symptoms.

The surface of the cerebrum is divided by fissures into convolutions, and somewhat arbitrarily into lobes. Thus the central fissure and anterior limb of the Sylvian fissure mark off the frontal lobe; between the central fissure in front, the parieto-occipital and transverse occipital behind, and the posterior arm of the fissure of Sylvius, below and to the side, lies the parietal lobe; behind the plane of the parieto-occipital fissure lies the occipital lobe; below the plane of the fissure of Sylvius, the temporal lobe.

THE RELATION OF THE CEREBRAL HEMISPHERES TO THE OUTER SURFACE OF THE SKULL

Before I describe the methods by means of which the various regions and the main fissures and convolutions of the hemispheres can be marked out on the surface of the scalp, a short account of the relations of the brain to the surface of the cranium is necessary.

The greater part of the cranial cavity is occupied by the cerebral hemispheres. Enveloped by the membranes, they fit closely within its walls, causing depressions and elevations on the inner surface of the cranial bones. The upper mesial borders of the hemispheres do not reach to the middle line, remaining separated from each other for ½ to 1 cm. Inferiorly the hemispheres reach nearly to the eyebrow in front, to the upper margin of the zygoma laterally, and to the superior curved lines of the occipital bone behind. Thus, if one desires to expose the under surface of a frontal lobe, one had best approach it on a level with the eyebrow (as is done in Frazier's approach to the hypophysis). If the surgeon desires to expose part of the base of the brain in the region of the temporal lobe, he must remain below the level of the zygoma (as is done in the low approach to the Gasserian ganglion according to Cushing, Lexer, etc.).

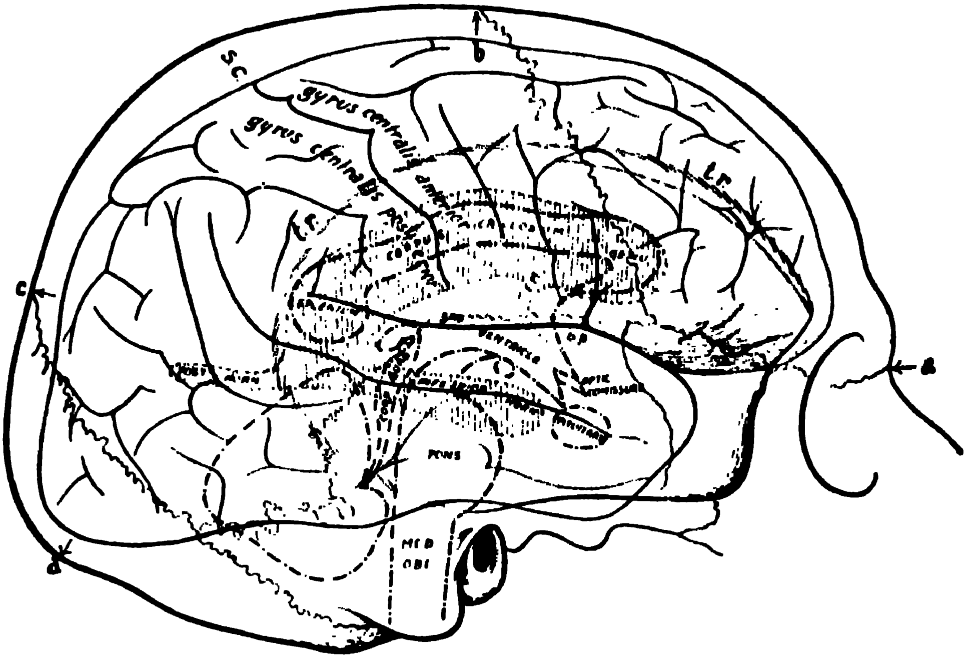

FIG. 1.—RIGHT LATERAL ASPECT OF SKULL AND CENTRAL HEMISPHERE WITH ORTHOGONAL PROJECTION OF STRUCTURES IN MEDIAN PLANE AND OF RIGHT LATERAL, THIRD AND FOURTH VENTRICLES. (J. Symington.)

The main parts of the upper and middle frontal convolutions correspond to the frontal region of the frontal bone, and the center of the frontal eminence is usually over the middle frontal.

The anterior central convolution and the bases of the frontal convolutions lie beneath the anterior third of the parietal bone; under the remaining parietal bone lie the parietal and sometimes a small part of the occipital lobe; the occipital lobe lies under the occipital bone to about the level of the superior curved line. The greater part of each temporal lobe lies beneath the squamous portion of the temporal and a small part of the parietal bone.

The whole of the third and lateral ventricles, excepting a small part of the posterior horn, lies, from the lateral aspect, within the area of the temporal fossa. The accompanying diagrams, after Symington, illustrate the extent and relations of these ventricles (Figs. 1 and 2).

Neisser and Pollack have given a detailed description of the points on the skull where punctures must be made for the exploration of various parts of the brain. The accompanying diagram from their paper gives the points which they recommend (Fig. 3). The main danger in performing brain puncture according to Neisser and Pollack's method is injury of important blood vessels, the middle meningeal artery or its main branches, the dural sinuses (especially the transverse sinus in puncture of the cerebellum), the large cerebral veins in the fissures of Sylvius, and large pial veins on the cortex and the base of the brain. On account of the danger of injury to these vessels, I believe that brain puncture should never be done without exposure of the cortex itself as described in the section on exploratory puncture of the brain.

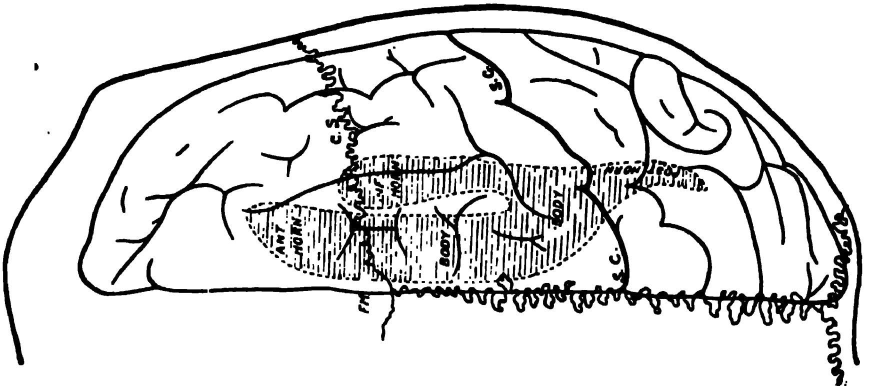

FIG. 2.—VIEW FROM ABOVE OF RIGHT HALF OF SKULL AND RIGHT CEREBRAL HEMISPHERE WITH PROJECTION OF RIGHT LATERAL VENTRICLE. (J. Symington.)

According to Steiner, the anterior branch of the middle meningeal artery lies under the point of crossing of two lines, the one a vertical which passes through the middle of a line drawn from the glabella to the tip of the mastoid process; the second, a horizontal at the level of the glabella.

The main artery lies under a point about five centimeters behind and a little more than 1 cm. above the zygomatic process of the frontal bone. This point corresponds to that recommended by Kocher and Poirier, a few centimeters above the middle of a line drawn from the external auditory meatus to the base of the frontal process of the malar bone.

The position and course of the transverse sinus will be described in the section devoted to the anatomy of subtentorial tumors. It is advisable to avoid puncture of the temporal lobe because injury to the large veins in the fissure of Sylvius is not always avoidable and the attempt should never be made to explore the base of the brain with a needle unless the brain has been well exposed through a craniotomy opening.

For exploratory puncture of the frontal lobes Neisser and Pollack recommend two points, one 4 cm. above the middle of the supra-orbital margin, and the second 4 cm. above the first point. The cerebellar hemisphere can be explored through a puncture opening made in the middle of a line which connected the tip of the mastoid process with the external occipital protuberance.

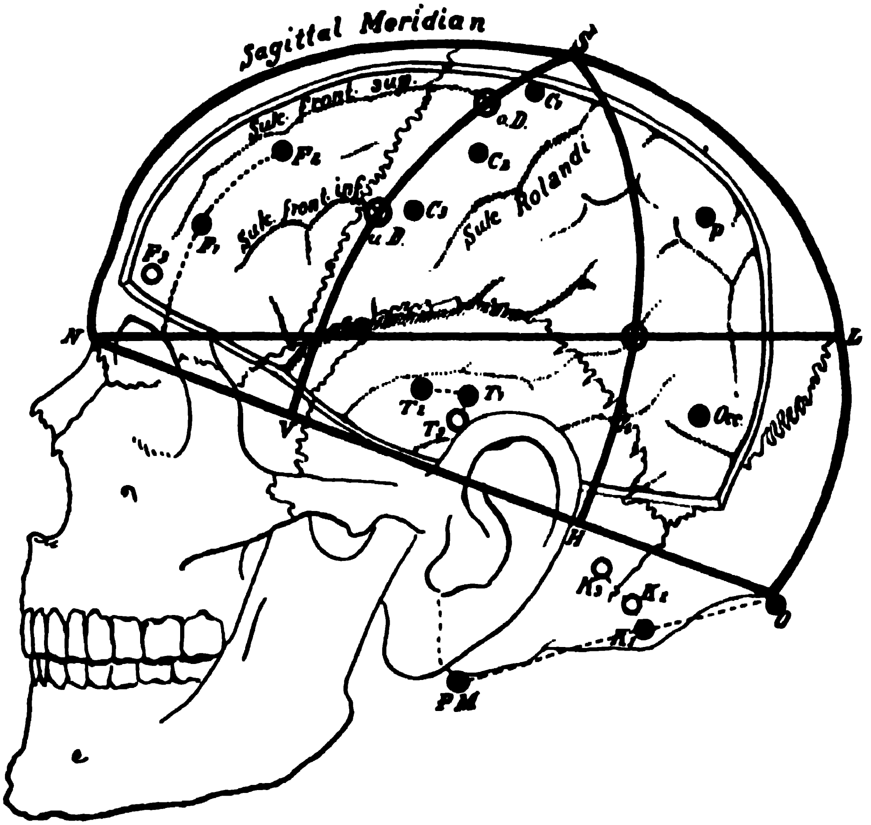

FIG. 3.—NEISSER AND POLLACK'S POINTS FOR PUNCTURE OF BRAIN. (Neisser and Pollack.) The black lines show Kocher's craniometer lines. The circles show Neisser and Pollack's points for aspiration of the brain for abscess, and the black spots show the points for aspiration of the various lobes of the brain according to these authors.

The middle of the temporal lobe is reached through an opening 1 to 1½ cm. above the lobe of the ear or 1 cm. in front of this point.

For an exploratory puncture of the Rolandic area, of the parietal and occipital lobes, one must first determine the location and extent of the fissure of Rolando as will be described in what follows, and then it will be easy to find the points for puncture from Neisser and Pollack's illustration.

When there is dilatation of the lateral ventricles, punctures of the exposed brain to a depth of two to four centimeters will usually reach some part of the ventricle, if the general direction of the ventricles is kept in mind. Puncture of the undilated ventricle is not always easy. The ventricle can be reached either through Kocher's point (2 to 3 cm. lateral to the point of junction of the

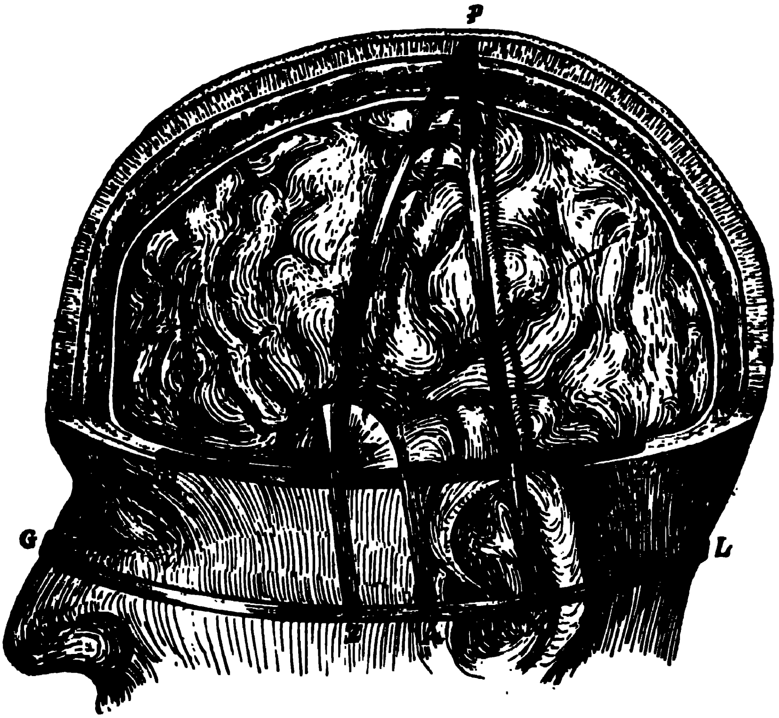

FIG. 4.—KRÖNLEIN'S MEASUREMENTS. (Braun.)

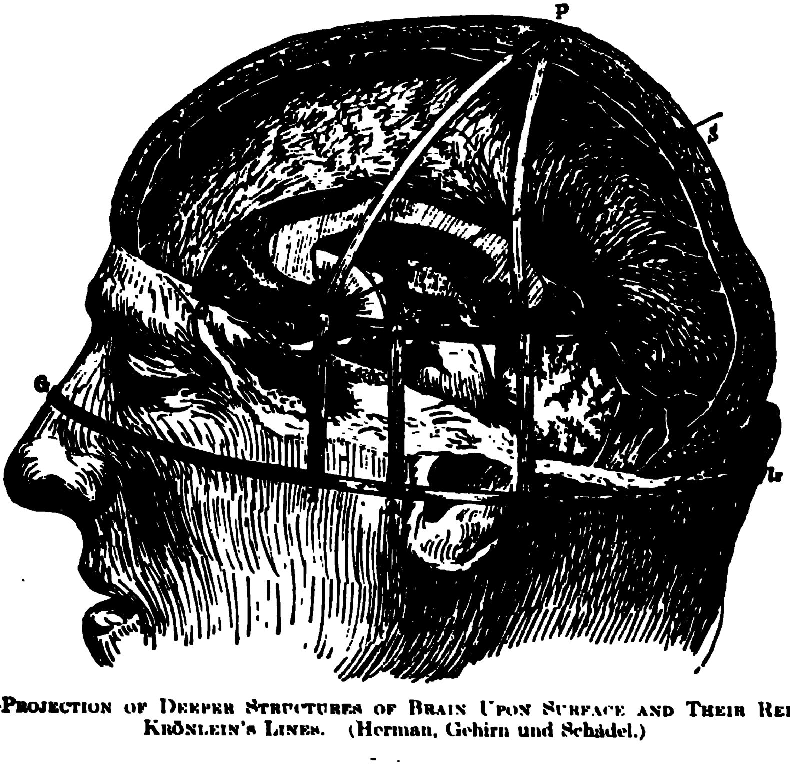

FIG. 5.—PROJECTION OF DEEPER STRUCTURES OF BRAIN UPON SURFACE AND THEIR RELATION TO KRÖNLEIN'S LINES. (Herman, Gehirn und Schädel.)

sagittal and coronary sutures), through Keen's point, or through the opening made for puncture of the corpus callosum.

For the determination of the location of the fissure of Rolando and the fissure of Sylvius upon the surface of the scalp, numerous methods have been recommended and numerous cyrtometers have been described. While I believe that Kocher's cyrtometer is the best, it is preferable to use a method in which apparatus of any kind is unnecessary. I have found that the well-known measurements of Krönlein give very satisfactory results. Krönlein's measurements have the advantage of being very simple and easily remembered.

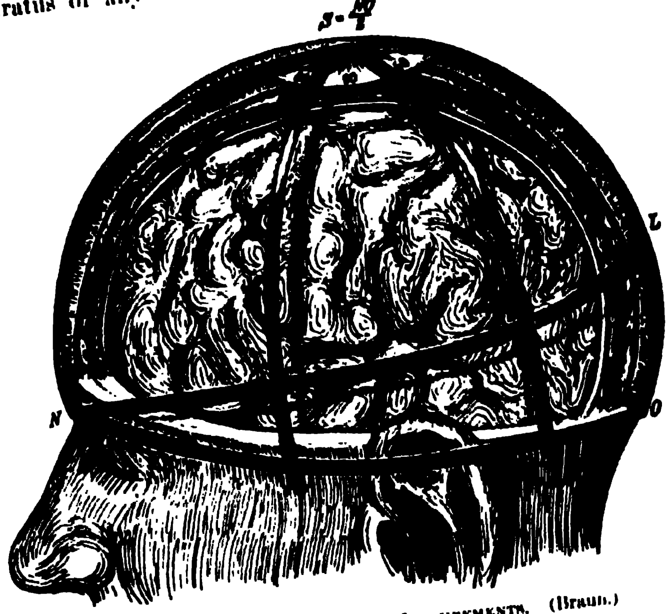

FIG. 6.—KOCHER'S CYRTOMETER MEASUREMENTS. (Braun.)

Krönlein's lines are the following:

1. A line from the lower margin of the orbit through the upper margin of the external auditory meatus.

2. A line parallel to line 1 at the level of the supra-orbital margin.

3. A vertical line at right angles to lines 1 and 2 over the greatest prominence of the mastoid process, at its posterior margin.

4. A vertical line over the middle of the zygomatic arch.

5. The Rolandic line. A line is drawn between the points of crossing of lines 2 and 4 to the point where line 3 crosses the median line of the head. The upper two-thirds of this line correspond to the fissure of Rolando.

6. The line which bisects the angle formed by lines 2 and 5 is the Sylvian line, the fissure of Sylvius lying between lines 3 and 4 (Fig. 4).

The accompanying figure from Hermann gives the projection of the mesially situated parts of the brain to the surface of the skull and to the measurements of Krönlein (Fig. 5).

By means of the method of Kocher, the position of the fissure of Sylvius and of the precentral fissure is easily determined, the steel bands of the cyrtometer being placed upon certain landmarks on the skull (Fig. 6). Although good results are possible with Kocher's cyrtometer, I have usually located the central convolutions more exactly by the method of Krönlein, and would therefore recommend the latter for general use.

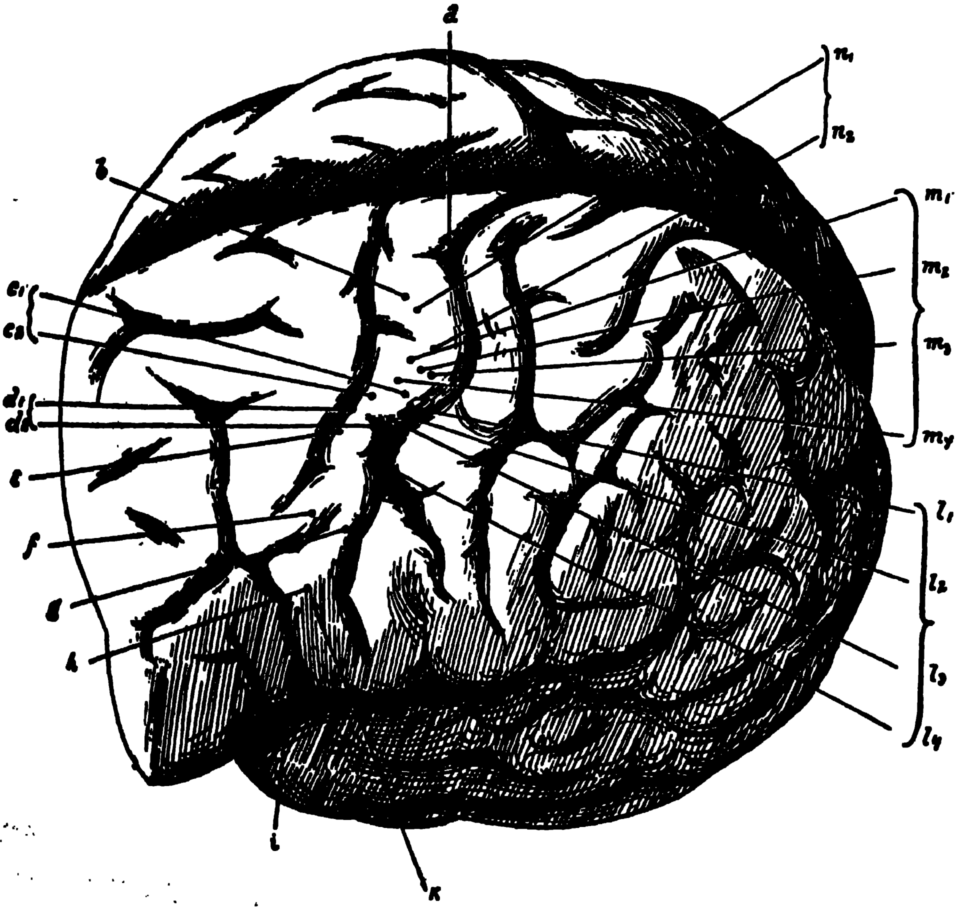

FIG. 7.—LEFT CEREBRAL HEMISPHERE WITH POINTS IN ANTERIOR CENTRAL CONVOLUTION WHICH RESPOND TO FARADIC STIMULATION. (Fedor Krause.) a—extension and inward rotation of foot; b—elevation and abduction of arm; c^1, c^2—flexion and extension of second, third, fourth and fifth fingers; d^1, d^2—extension and flexion of index finger; e—extension of fifth finger; f—contralateral eyelids; g—angle of mouth; h—mm. zygomatic and levator labii superioris; i—masseter; k—external pterygoid; l_1, l_2, l_3, l_4—contraction, opposition, extension, marked flexion of thumb; m_1, m_2, m_3, m_4—ulnar flexion, palmar flexion, radial flexion, dorsal flexion of wrist; n_1, n_2—extension and flexion of elbow.

In order to be able to determine the location of centers on the surface of the brain, the surgeon must have a good working knowledge of cerebral localization. Our knowledge of cerebral localization is based upon the researches of Ferrier, Horsley, Munk and others upon monkeys, and upon the results of faradization of the exposed human brain by Horsley, Krause, Cushing and others. The accompanying diagrams from Krause and from Horsley give a good idea of our knowledge up to the present time (Figs. 7 and 8).

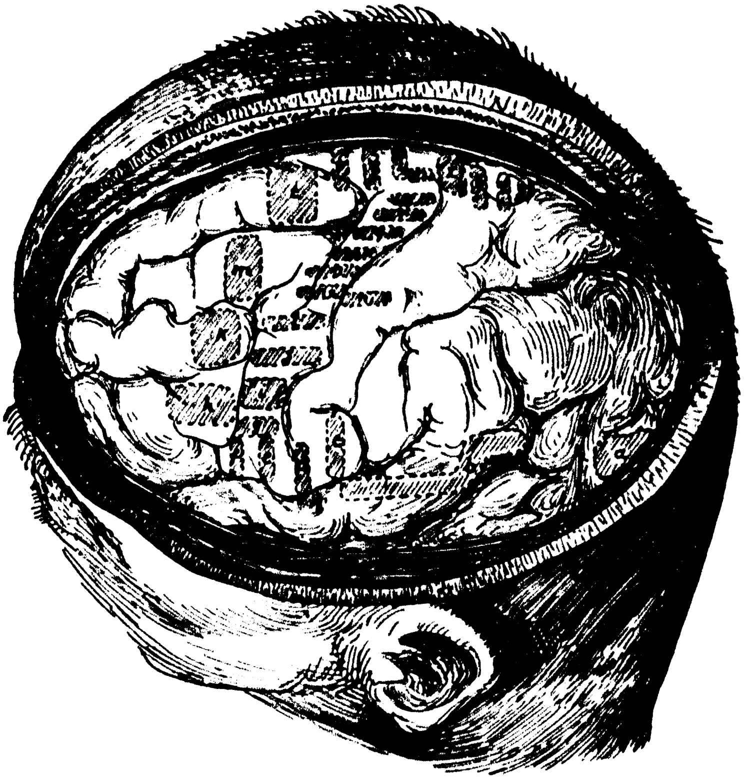

FIG. 8.—CEREBRAL LOCALIZATION. (Horsley.) a—visual area; b—sensory speech; c—platysma; d—chewing; e—larynx; f—tongue; g—movement of opening mouth; h—motor speech; i—retraction of angle of mouth; j—raising angle of mouth; k—contralateral movements of eyes; l—contralateral closure of eyelid; m—contralateral turning of head and movement of eyes; n—movements of thumb; o—movement of index finger; p—movement at wrist; q—movement at elbow; r—movement of shoulder; s—movement at hip; t—turning of head to opposite side; u—movement of trunk; v—hip; w—knee; x—movement at ankle joint; y—large toe movement; z—movement of smaller toes.

It will be a great help to the surgeon who desires to become expert in cranial surgery to study the situation and variations of the main fissures and convolutions in a large number of human brains, so that he will have a good idea of the differences in shape and direction. Dissection of a number of skulls in order to determine the correspondence of craniocerebral measurements as marked out on the scalp and the actual position of the fissures will be found to be of value. As Froriep has shown, most brains in their relation to the skull cavity follow either a frontipetal or an occipitopetal type. In the former class belong all brains in which the frontal part occupies relatively a large part of the cranial cavity and in these the central fissure occupies a more vertical position. In the occipitopetal type a larger part of the cerebral hemispheres lies posterior to a vertical line drawn through the external auditory meatus, and in these the central fissure runs obliquely backward. Other differences depend upon age and race.

EXPLORATORY PUNCTURE OF THE BRAIN; ASPIRATION OF THE VENTRICLES

Historically it is of interest that Middeldorpf proposed exploration of the brain by means of aspiration as early as 1856. He was followed by Maas, Gibier and Spitzka, Schmidt, Payr, Kocher and others, but our real knowledge of this procedure dates from the publications of Pollack and Neisser. They proposed the routine exploration of the brain for diagnostic purposes, by means of aspiration with a small needle through a small drill opening in the skull, and recorded a large number of cases in which they had been able to locate collections of blood, of pus, and tumors by this means. By aspiration of the brain they were able to remove small bits of tumor tissue and thus definitely localize otherwise unlocalizable new growths. They claim that the method is a very simple one, almost free from danger, and described the points on the surface of the skull where the puncture should be made in order to reach definite parts of the brain.

With a small electric drill 2 to 4 mm. in diameter, under local anesthesia (or general anesthesia, if necessary) the bone is punctured, care being taken that the drill is withdrawn as soon as the bone has been perforated. It is unnecessary to make an incision in the scalp, for the rapidly revolving drill will penetrate that soft part without trouble. Through the drill opening an aspirating needle with stylet is passed until the resistance of the dura is felt. If an extradural collection of fluid is suspected, the stylet is withdrawn from the needle, the syringe attached and aspiration performed. If a subdural collection of fluid is suspected, the needle is pushed through the dura and aspiration done.

Sometimes it is difficult to find the drill hole in the bone with the needle because the scalp has been moved away from over the small opening, and various devices have been suggested to fix the soft tissues of the scalp during the drilling of the bone and the introduction of the needle. I have never found it necessary to employ any of these. If the scalp is well supported while the bone is being drilled, it is usually easy to find the drill opening in the bone with the point of the aspirating needle. At the worst, the operator has to move around the needle a little until the opening is found.

When aspiration of the brain is to be performed, the needle with the stylet in place is gently pushed into the brain a short distance, the stylet withdrawn, the syringe attached and aspiration done. The brain tissue obtained is carefully kept for examination. If necessary, the needle is pushed deeper and further specimens of tissue obtained. Various parts of the brain—cerebral lobes and the hemispheres of the cerebellum can be explored in this manner.

The needle to be used should be blunt at its point (Fig. 9) and should be marked off in centimeters. It should have a well-fitting stylet.

I do not believe that exploratory brain puncture should ever be performed on account of the danger of injury to large pial vessels. It is perfectly safe to explore the extradural and intradural spaces for collections of fluid, but when the brain itself is to be aspirated, a trephine opening in the skull followed by a small incision in the dura should be made, with exposure of the surface of the brain, and selection of a spot on the cortex which is free from pial vessels. Nevertheless, the method of Neisser and Pollack is worthy of mention. The diagram from Neisser and Pollack's paper shows the points on the skull through which they made their punctures. I have referred to these points in detail in the section devoted to craniocerebral topography (Fig. 3).

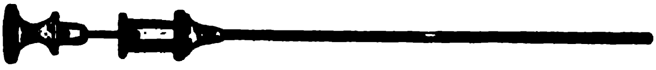

FIG. 9.—NEEDLE WITH STILET FOR PUNCTURE OF VENTRICLES.

When an opening in a part of the skull is made with a drill or trephine and a small incision in the dura added, aspiration of the brain itself is practically without danger, and this method is the one to be used, not only for exploration for abscess, cyst, or tumor, but also for aspiration of the ventricles and, when indicated, for injection of fluid into the ventricles.

At any time during the course of a cranial operation, aspiration of the ventricles may be necessary, and with a knowledge of the size and location of the lateral ventricles, the surgeon should have no difficulty in reaching the ventricles from any part of the brain he has exposed. If the ventricles are dilated, they can usually be punctured with ease. For the exact location of the ventricles I refer the reader to what is said in the section devoted to craniocerebral topography. The lateral ventricles can be reached with an aspirating needle from any part of the exposed cerebral hemispheres. If it is desired to aspirate the lateral ventricle in the course of a subtentorial operation, it is advisable to remove a little of the occipital bone in an upward direction until the dura over an occipital lobe is exposed, then to make an incision ½ cm. in length in the dura, and through this to introduce the needle.

For aspiration of the ventricles as an operation per se, one of the following methods should be adopted: In infants a needle should be introduced downward and a little backward through the lateral angle of the anterior fontanel; at a distance of 2 to 4 cm. the needle will enter the lateral ventricle. As the needle, armed with its stilet, is introduced, the surgeon must be careful that the needle is kept pointing in one direction so that no injury to the brain occurs. As soon as the needle has been introduced for 2 to 3 cm., the stilet is withdrawn, and the needle then carefully pushed forward until fluid is obtained. If the fluid does not run well, it is perfectly safe to attach a syringe and slowly draw out the fluid. This must be done with great gentleness, the left hand, supported on the patient's head, holding the needle in place. No matter how marked the distention of the ventricles nor how great the pressure of fluid, no more than 50 to 60 c. c. should ever be withdrawn at one time. If a fluid or serum is to be introduced, it is advisable to remove at least as much cerebrospinal fluid as is to be injected. In the hands of the experienced brain surgeon it is safe to inject the fluid with a syringe; it is usually better to allow the fluid to run in through a small sterile glass funnel with a rubber connecting piece. If the fluid will not run in well, the funnel can be raised the required distance above the head of the patient.

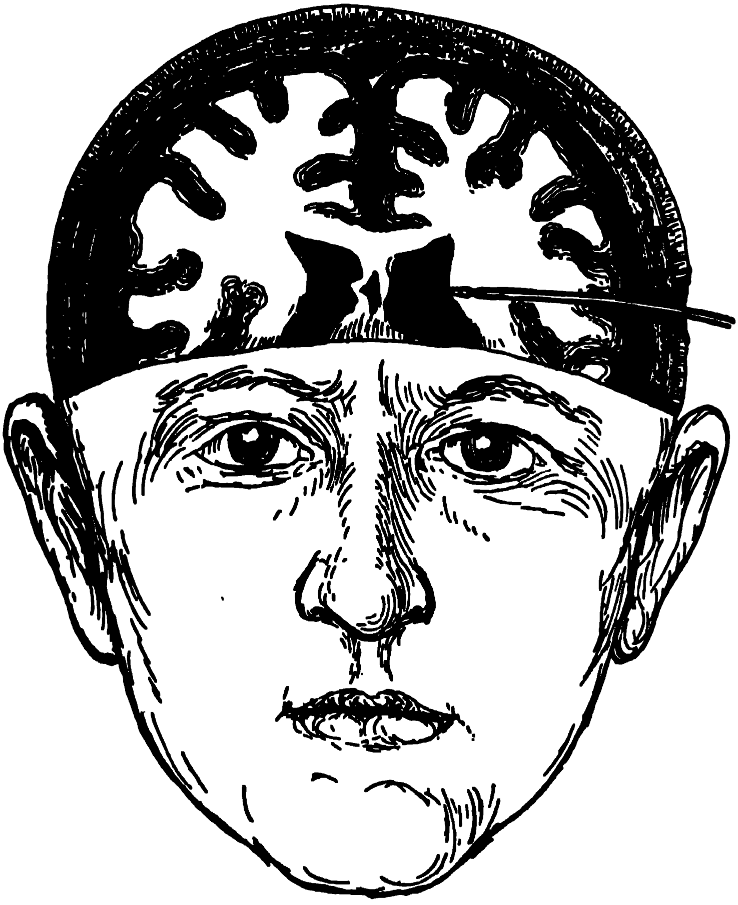

FIG. 10.—PUNCTURE OF LATERAL VENTRICLE—KEEN'S METHOD.

Aspiration of the ventricle in adults or in children in whom the anterior fontanel has closed, must be done either from the side (Keen, Fig.

10) or from near the median line (Kocher, Fig. 11). At a point about 3 cm. behind and 3 cm. above the external auditory meatus, a small incision is made in the scalp, a button of bone removed with the trephine, a small incision made in the dura, and a needle with blunt end introduced directly inward pointing toward the external auditory meatus of the other side. At a depth of about 5 cm. the ventricle is punctured. I do not believe that this lateral aspiration of the ventricle is as safe as the method of Kocher because the width of the ventricle is much less than its depth and therefore it is much more likely that the opposite wall of the ventricle will be injured by the point of the needle when the latter enters it in a transverse direction.

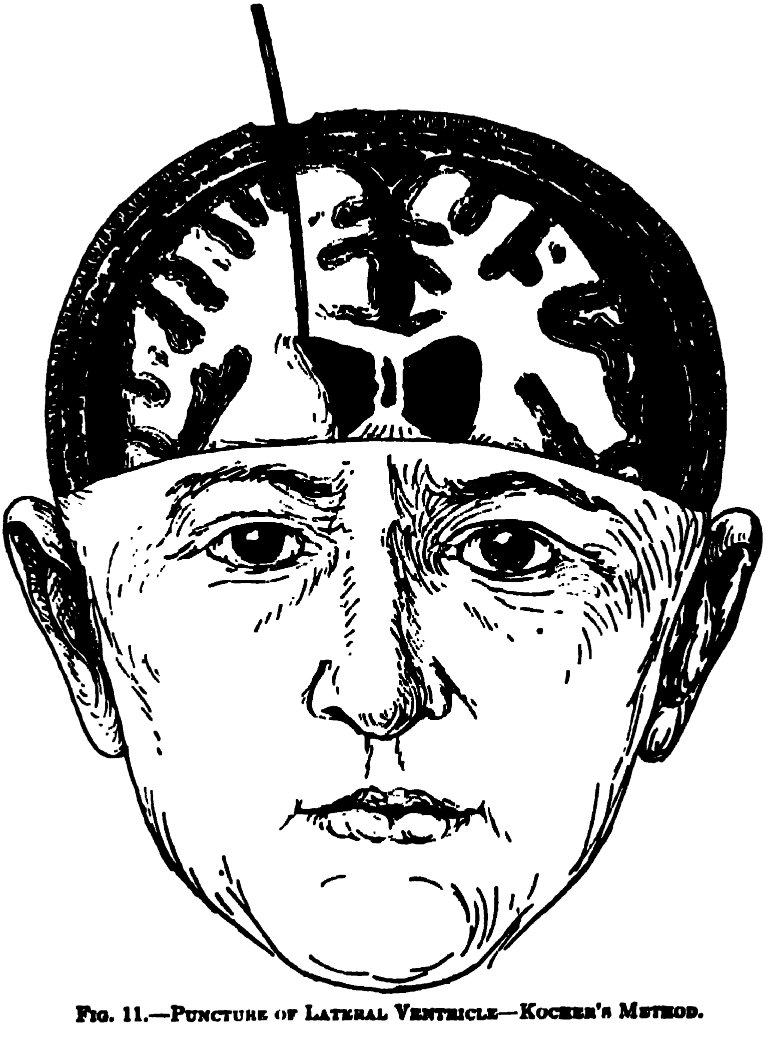

FIG. 11.—PUNCTURE OF LATERAL VENTRICLE—KOCHER'S METHOD.

The best method for aspirating the ventricle is from above according to the procedure of Kocher. The point at which the scalp is incised and the trephine is applied to the bone is the same as that for puncture of the corpus callosum (q. v.). The scalp is incised in a transverse direction for about 3 cm. beginning just behind the coronal suture and about 2 cm. from the median line. In the middle of this incision a button of bone is removed with the trephine, a small incision is then made in the dura, and the needle introduced downward and perhaps very slightly backward (Elsberg) to a depth of 5 to 6 cm., when the ventricle will be entered by the point of the needle. The needle must be carefully supported by the operator or an assistant so that its direction may be kept constant while the fluid is escaping so that it will not be pushed in more deeply during the manipulations.

Fraser recommended that the lateral ventricle should be aspirated through the posterior part of the first temporal convolution, but, as above mentioned, the method of Kocher is the best and safest procedure for ventricular aspiration.

The operation of ventricular puncture is without danger. It can often be done under local anesthesia. Aspiration of the ventricle through the anterior fontanel in infants requires no anesthetic.

In a number of instances I have endeavored to benefit cerebrospinal meningitis and posterior basic meningitis by means of a washing out of the entire ventricular system. For this purpose one needle is passed into the ventricle and another into the spinal subarachnoid, and through-and-through irrigation attempted. If the foramen of Magendie is not closed, the through-and-through irrigation can be done. The fluid is allowed to run into the one needle under a very low pressure by means of a moderate size funnel which is raised a few inches above the level of the ventricle, and will be found to drop out slowly through the spinal needle. It is advisable to color the fluid with a little sterile methylen blue solution so as to have an indicator that the fluid is really running. I have used saline solution and 1 : 1,000 tincture of iodin solution for the irrigation and have continued the washing out of the ventricular system for one-half hour. Some of the patients were undoubtedly improved for a time, but none of them was definitely cured. The method deserves further trial.

TECHNIC OF INTRACRANIAL OPERATIONS

Some one has said that the operation of trephining is "as old as the hills"; it is certain that the skull was trephined in old times, for even Hippocrates speaks of the "antiquity" of the operation. Trephining was performed during the Neolithic period, for skulls with openings exist in ethnological collections all over the world. Sharpened shells and flints were the rude instruments employed, the operations being done to oust "evil spirits" from the heads of individuals suffering from epilepsy and insanity.

The hand trephine was known to the ancients in a form not differing essentially from that of modern times, and good specimens were discovered in the ruins of Pompeii and are on exhibition in the Pompeian Museum in Naples. The operation of trephining is depicted in many old prints of the twelfth and sixteenth centuries.

During the seventeenth and eighteenth centuries the operation was performed very often for fractures of the skull, and in the writings of the day we find cases which are cited to illustrate the beneficial effects of the operation. (See Gallez, "La trépanation du crane"; Lucas-Championnière, "Étude historique et chirurgique sur la trépanation du crâne," etc.)

The introduction of aseptic surgery, the knowledge of the differentiation of functions in different parts of the brain, and the technical advances since Wagner's osteoplastic flap method have altered the entire character of the operation of craniotomy, bringing it out of the narrow field where small openings were made for traumatic lesions into the wide field where the skull was opened without fear for a large variety of intracranial affections.

There is no more attractive study for those who are interested in the history of medicine than the gradual development of the operation of trephining; only the above short consideration of the subject can be given.

GENERAL PRINCIPLES UNDERLYING CRANIAL SURGERY

Shall the Opening in the Skull Be Made by Removal of the Bone or by Osteoplastic Flaps?- Some surgeons, foremost among whom is the Nestor of Neurological Surgery, Sir Victor Horsley, remove the bone entirely, leaving behind a large defect in the walls of the cranial chamber. Most operators, however, prefer to make osteoplastic flaps whenever possible, so as to restore the integrity of the bony walls at the conclusion of the operation. In the drainage of an abscess a simple trephine opening will often suffice, for the exposure of one or both cerebellar hemispheres the bone had better be sacrificed, and also for the exposure and removal of the Gasserian ganglion or the division of the sensory root of the trigeminus. As I have already mentioned, the bone must always be removed for a cerebral or cerebellar decompression.

Sometimes it is necessary to combine the two methods. Thus in the exposure of lesions in the temporosphenoidal lobe, I have frequently made an osteoplastic flap with its base in the subtemporal region, and for better exposure have rongeured away the bone below the base of the flap well down to the floor of the middle cranial fossa. Similarly, in Frazier's operation for the exposure of the hypophysis through the anterior cranial fossa, an osteoplastic flap is turned down over one frontal region, and the orbital roof rongeured away as far back as the optic foramen.

Osteoplastic flaps must always be made rather too large than too small. As was pointed out by Hartley, the base of an osteoplastic flap should be in the thin-boned temporal region whenever possible; at least one part of the circumference of the bone flap should be beveled so that no pressure upon the dura can occur when the flap is returned into place.

One- or Two-Stage Operations.—Horsley was the first to suggest that operations for intracranial disease should be done in two stages, the opening in the dura and the intradural manipulations being reserved until the second operation. By this means the mortality of operations for brain tumor has been much decreased. I believe that operations for tumor beneath the tentorium should always be done in two stages, but that many operations for tumor or other disease of the cerebral hemispheres can be done at one sitting. If the condition of the patient is good when the skull is open the operation can often be successfully concluded at the one stage. It is no little trial for a patient to be subjected to two anesthesias and operations. In about one half of the cases I have had I have been able to do a one-stage operation. It is hardly necessary to state that at the conclusion of the first part of a two-stage operation the wound must be sutured as carefully as if the surgical interference had been definitely completed.

Shock in Cranial Operations.—Much has been written concerning the shock of cranial operations, but I agree with those who believe that most patients stand the interference well if done by the trained and expert worker in this special field. Formerly I was accustomed to have blood-pressure estimations made during the course of every intracranial operation. After Cushing and Frazier had called especial attention to the variations in pressure during these operations, and the frequency of sudden falls in the pressure during intracranial manipulations, I made continual use of the method. Since I have learned to control bleeding, and to shorten the length of my operations, I have found less and less use for these blood-pressure estimations. The "shock" of a brain operation is to a large degree proportionate to the amount of blood lost and the roughness of manipulations. Cushing, than whom there is no more experienced operator, well states the condition of affairs: "I am well aware that it is a common belief that cranial operations are prone to cause 'shock,' but it is a personal conviction, due to careful observation of blood pressure changes in these operations, that so-called shock, in the majority of cases, is due either to loss of blood or to cerebral trauma (concussion) brought on by injudicious methods of entering the skull." I would add, too rough handling of brain tissue and sometimes excessive faradization of the cortex.

Marked pallor, fall in blood pressure, weak and rapid pulse, and irregular respiration are apt to occur during subtentorial operations, and the surgeon must be extremely careful in his manipulations around the pons and medulla. The suboccipital opening should always be a large one, and the bone should be removed into the foramen magnum on both sides.

For the exposure of cerebral lesions a large opening in the skull must be made; **in not a few cases brain tumors have not been found at the operations because the opening was too small.** The larger the craniotomy the less will the surgeon, during the removal of a tumor, be troubled by the prolapse of the brain. Thus for the exposure of a part of the motor convolutions the entire Rolandic area and the adjacent convolutions must be laid bare; the exposure of the temporal lobe requires a bone flap, laying bare also parts of the parietal and occipital regions.

TECHNICAL DETAILS OF IMPORTANCE IN CRANIOTOMY AND CRANIECTOMY

1. **The Prevention of Hemorrhage.**—Horsley declares that chloroform should be used in all cranial operations on account of the fact that less bleeding occurs. Most surgeons, however, use ether by preference (Cushing, Krause, Borchard, Frazier, etc.), and I agree with Cushing that the danger from chloroform more than balances the increased bleeding during operations under ether anesthesia.

The amount of bleeding from the scalp and brain is distinctly less when the head of the patient is on a higher level than the rest of the body; the head end of the operating table should therefore always be raised during the operation. Occasionally it is of advantage to have the patient in an almost sitting position (Fig. 12), and Frazier has devised an operating table for this purpose.

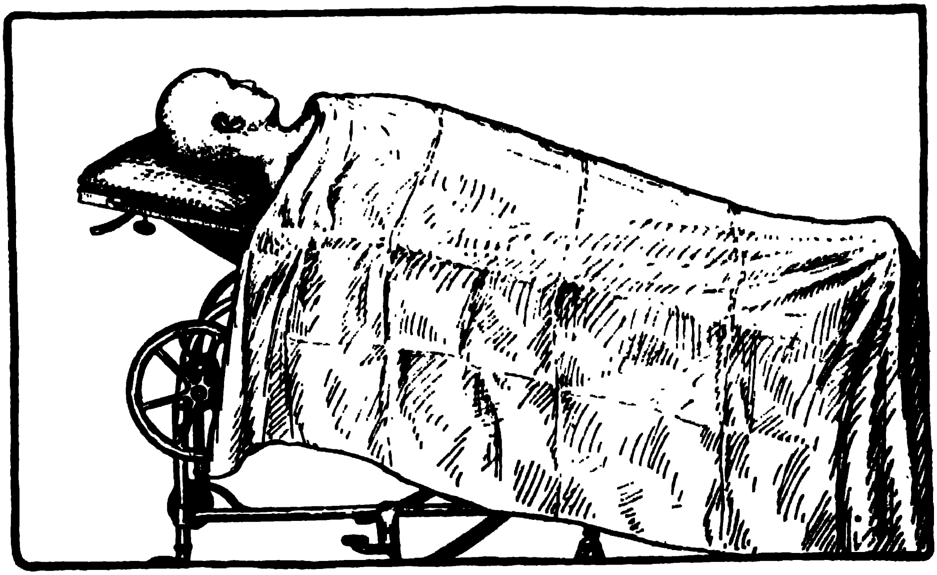

FIG. 12.—POSITION OF PATIENT FOR CRANIAL OPERATION.

The scalp is a very vascular tissue, and many methods have been devised to prevent loss of blood when the scalp incision is made. In many cases a complete hemostasis can be obtained by means of the elastic tourniquet, which is applied tightly around the head. This tourniquet must lie over the supraorbital ridges, below the external occipital protuberance, and just above the lobes of the ears. A number of elastic tubes or bands have been devised for this purpose (Cushing, Brewer, etc., Fig. 13), but the tourniquets have a great tendency to slip upward or downward over the frontal region. It is, therefore, necessary to have a tape which connects the frontal and occipital parts of the elastic tube. I believe that the easiest and best method for the prevention of hemorrhages from the scalp is by means of the suture recommended by Heidenhain. Instead of the double row of sutures described by Heidenhain, I usually pass one continuous suture around the area to be made anemic and within which the scalp incision is to be made. I generally use stout chromic catgut on a full curved needle, and pass the needle through all the tissues down to the bone (Fig. 14), so as to be sure to catch the large vessels which run in the periosteum. The needle must be entered a little behind the spot where it last emerged, thus forming a series of loops in the scalp. At the conclusion of the operation, and after the scalp has been sutured, the loops of the running suture are cut and removed.

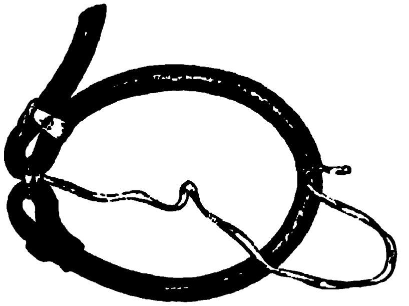

FIG. 13.—TOURNIQUET WITH TAPE TO PREVENT SLIPPING. (Cushing.)

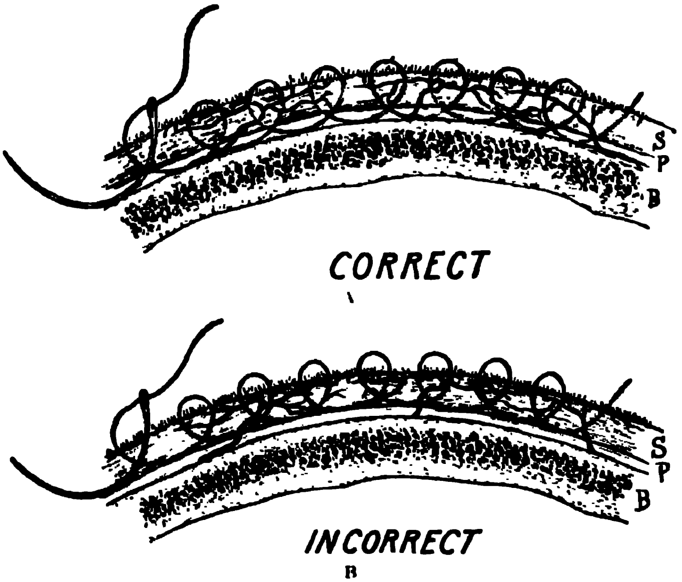

FIG. 14.—HEMOSTATIC SUTURE OF SCALP. (Heidenhain.) A shows the correct and B the incorrect suture.

I have had no experience with the plates described by Kredel or the various forceps or other devices that have been suggested, for I have found the modified

Heidenhain suture to be entirely satisfactory. When a small incision only is made in the scalp no suture of any kind is necessary, for the few bleeding vessels can be caught with artery clamps.

Hemorrhage from the bone can usually be controlled with the so-called Horsley wax—ordinary bees' wax which has been boiled in 5 per cent. carbolic solution to make it sticky. Bleeding from large bone sinuses may be very profuse; this bleeding often requires that a small wooden plug be hammered into the opening and various sized wooden plugs sharpened at one end must be kept ready.

Hemorrhage from one of the venous sinuses can usually be controlled by gauze packings, but sometimes the sinus must be ligated. For this purpose a small incision is made in the dura well outside of the edge of the sinus on each side, and an aneurysm needle with catgut or silk passed around the sinus, care being taken that the needle is passed well below the sinus. In ligating the longitudinal sinus the falx cerebri has to be perforated; in the case of the transverse sinus the tentorium has to be punctured with the needle. The longitudinal sinus is about 6 to 8 mm. wide in its anterior part, and it becomes gradually wider until it is 12 to 15 mm. wide near the external occipital protuberance.

It is, however, rarely necessary to pass a ligature around a sinus unless the sinus is to be completely divided or a part of it is to be resected. It is generally possible to stop bleeding by packing the lumen of the sinus with a small pledget of gauze. Very often the wound of the sinus can be closed by a running suture of fine silk, after pressure has been made on both sides of the point of injury. I have several times controlled the hemorrhage after the method of Revenstorf. A needle with suture is passed in and out of the dura on each side of the sinus; the suture is then tied and the sinus wall thus compressed. Two or three sutures passed in this way will usually suffice to stop even a very active hemorrhage.

For the control of bleeding from the brain tissue a number of devices are useful. Vessels that can be grasped with fine artery forceps must be ligated. General oozing from the brain tissue will generally stop after a short compression of the bleeding surface with a gauze sponge wrung out in hot saline solution. Bleeding can also be controlled by means of pressure with small bits of sterile absorbent cotton, but the operator must be careful that all of the pieces of cotton are removed before the wound is closed. Oozing of blood from a small area can be very satisfactorily controlled by means of pressure with a small piece of muscle tissue cut from the edge of the scalp wound. The piece of muscle becomes adherent in a few moments and is allowed to remain.

Before the cortex of the brain is incised pial vessels of any size must be doubly ligated. The bleeding from cut pial vessels, even if not profuse, is very disturbing, for the surface of the cortex quickly becomes covered with a layer of blood and the fissures are then more or less obliterated.

2. Faradization of the Cortex.—Faradization of the cortex is used to determine the location of centers in the Rolandic area. For this purpose a unipolar electrode is best used constructed after the model of Cushing (Fig. 15). This consists of a platinum wire insulated by means of a piece of rubber tubing and inclosed in a piece of glass tubing. The other pole is an ordinary sponge pad applied to some part of the body of the patient. The unipolar electrode of Cushing can be boiled, and on account of its length can be handled by both the operator and the assistant who controls the electric battery. The current used should be just strong enough to cause a slight muscular contraction when applied to the tongue.

In order to pick out exact areas on the cortex by means of faradization the pia mater must be pricked open with a needle or the point of a scalpel so that the electrode is applied directly to the cortex. Otherwise there will be too much diffusion of the faradic current.

FIG. 15.—CUSHING'S STERILIZABLE ELECTRODE.

As Krause was the first to point out, the cortex does not respond to the faradic current in some individuals. In the majority of instances, however, prompt responses to the current will occur.

Before the electrode is applied to the cortex the face of the patient and the upper and lower extremity of the side opposite to that on which the brain is exposed should be uncovered, and an assistant instructed to watch the parts for the least muscular twitching or contraction.

Faradization should not be long continued; when the area desired has been located the electrode should be removed. After long-continued faradization the patient sometimes shows symptoms of shock, and I have once observed marked irregularity of the pulse for a number of minutes after the faradization had been discontinued.

3. The Value of X-Ray Examinations in Cranial Surgery.—Numerous attempts have been made to demonstrate the presence of a brain, tumor on the X-ray plate, but in the majority of instances these have been unsuccessful. It may be that in the future, with a greater refinement in X-ray technic, we shall be able to determine the presence or absence of a new growth by this means; up to the present almost the only tumors that have been shown by X-ray examination are the following: Bony tumors arising from the cranial bones and new growths which have undergone calcareous changes (hypophyseal and parahypophyseal growths and some tumors of the pineal gland).

The localization of a new growth may be made by means of the X-ray if erosion of part of the skull has occurred, as I observed in one instance. The X-ray is of value in the determination of the size and shape of the sella turcica and of the frontal and sphenoid sinuses before an operation upon the hypophysis. X-ray plates will give the surgeon a good idea of the thickness of the skull upon which he is going to operate, of the location of the bony fissures, and of the large branches of the meningeal arteries.

That the X-ray is indispensable for the localization of foreign bodies (bullets, etc.) and of fractures of the vault and base is mentioned only for the sake of completeness.

An X-ray examination of the skull should therefore be made before every intracranial operation, and will sometimes give most valuable information.

4. **The Closure of Defects of the Dura and the Bony Skull.**—Rarely the necessity of closing a defect of the dura arises after a cranial operation. This is best accomplished by fascial transplantation. A piece of the fasciæ lata of the patient a little larger than the defect which is to be filled is removed from the thigh, cut into shape, and accurately sutured into place in the dura. The fascial transplants heal in very satisfactorily.

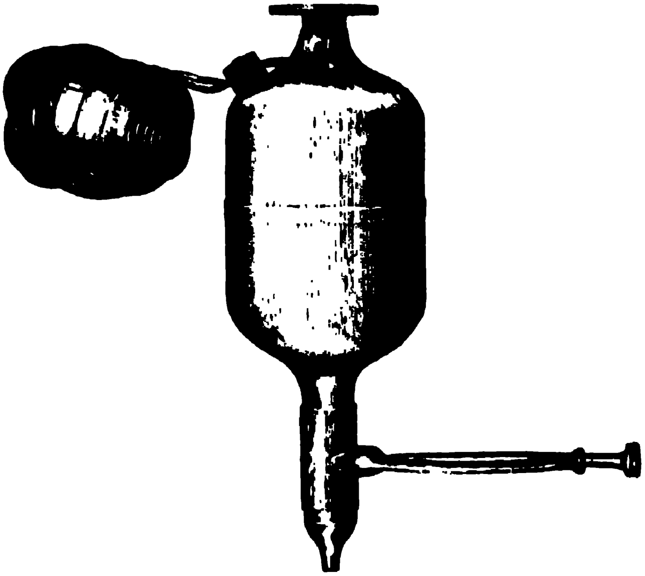

FIG. 16.—HARTLEY AND KENYON'S STERILIZABLE MOTOR.

Occasionally defects in the bony skull, left after cranial operations for fracture of the skull or for intracranial disease, require to be closed. A number of osteoplastic operations have been suggested and numerous plates of various materials (celluloid, silver, aluminum, etc.) have been recommended. It is not advisable, I think, to implant a foreign substance into the skull. Sooner or later these plates have caused trouble and have had to be removed. If a defect in the skull must be closed one should do an autoplastic or heteroplastic bone transplantation. A large piece of the patient's tibia can be removed and the defect in the skull partially closed with it. I have once succeeded in closing a large defect in the skull left from a former operation by transplanting a large piece of skull from another patient from whom the bone had just been removed in the course of a cranial operation.

5. **Instruments and Methods for Opening the Skull.**—When a craniectomy is to be done a button of bone is removed with a trephine or an opening made with a burr, and the bone then rongeured away with variously sized forceps. The making of the primary opening with mallet and gouges is a barbarous procedure and should not be countenanced. If an osteoplastic flap is made various devices and instruments are useful, depending upon the custom of the operator.

The electromotor has been employed to furnish the driving power for a number of instruments, for drills and burrs, for circular saws and trephines. Among the instruments most used may be mentioned the following: Van Arsdale's, Marsland's, Doyen's, and Hartley and Kenyon's saws. In these saws a primary opening is made with a trephine or drill, the opening enlarged with a burr, and the bone then cut from without inward with the circular saw. Doyen's and several other saws have a dural guard so as to protect the dura from injury. Hartley and Kenyon have made the improvement of having the drill and saw directly connected with the motor. Their motor weighs 8 to 9 pounds, can be sterilized, and is to be held by the operator (Fig. 16).

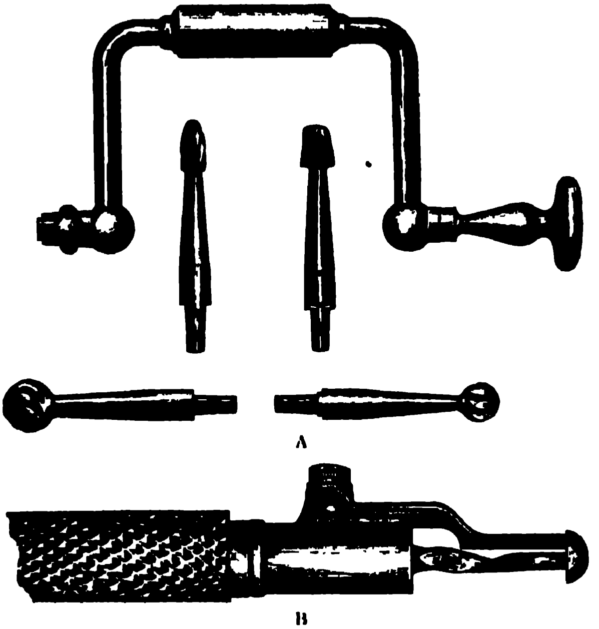

FIG. 17.—A—HUDSON'S DRILLS. B—CRYER'S SPIRAL OSTEOTOME.

Revolving drills with spiral cutting edges, the so-called fraises, are highly recommended by some operators, but such instruments as the fraise of Sudeck and the spiral osteotome of Cryer possess the disadvantage that they cut a wide slit in the bone, so that when the osteoplastic flap is replaced the flap rests directly upon the dura. While it is true that with most of the saws or fraises above mentioned an osteoplastic flap can be made somewhat more rapidly than in the manner I shall describe, I still prefer to make the flap with bone-cutting forceps of the Montenovesi, Dahlgren, or Hudson type.

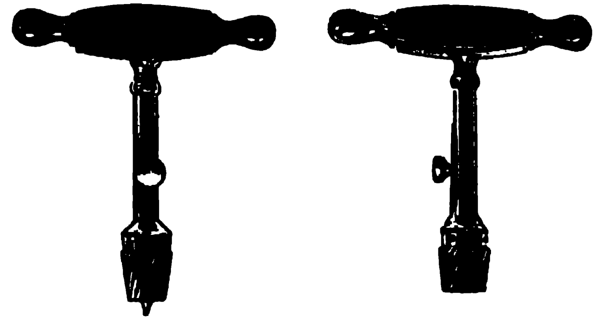

FIG. 18.—SPIRAL HAND TREPHINES. A preliminary groove is made in the bone with the trephine which has a projecting point.

It is practically impossible to injure the dura with these tools, and a large bone flap can ordinarily be cut in from 10 to 20 minutes.

While the drills of Hudson (Fig. 17), which lock as soon as the bone has been perforated, are very useful in regions of the skull where the bone is thick, I do not think that they will always lock when they are used to drill openings in thin bone, and I have become accustomed to use the ordinary hand trephines (Fig. 18) for the purpose. One feels when one has almost gone through the bone, and if the instrument be now tilted a little, the button of bone can be broken out. I have never injured the dura with these trephines, but I have several times witnessed cuts or tears in the dura when a circular saw or a fraise was used.

The method followed and the type of instrument used will depend very much upon the custom of the operator; in the following I shall describe the method which I have adopted:

THE OSTEOPLASTIC PROCEDURE

After the location and size of the osteoplastic flap have been outlined on the scalp a continuous "back stitch" suture of chromic catgut is passed about 1 cm. outside of the proposed incision all around the operative area. The soft tissues are then incised down to the bone with the scalpel, care being taken that the periosteum is cut. With a sharp raspatory the periosteum is pushed away from the bone over an area roughly one centimeter wide all around. With an ordinary crown trephine 4 openings are made in the skull, 2 at the base of the flap, and 2 at its extreme margin. As each trephine opening is made hemorrhage from the bone is controlled with Horsley's wax or with a small gauze sponge. The 2 trephine openings near the upper end of the proposed flap should be no more than 4 or 5 cm. apart, because between them the bone is to be divided on the bevel. With the Hudson forceps (Fig. 19) a slot is now cut all around excepting between the two trephine openings just mentioned. The slot is cut also into what is to be the base of the bone flap so as to make the fracturing of the base of the bone flap more easy.

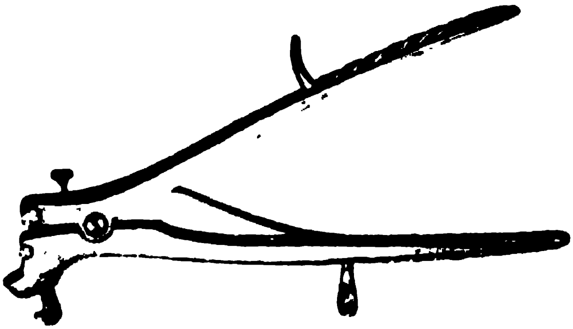

Fig. 19. Hudson's Cranial Forceps.

A dural protector (Fig. 20) is passed between the 2 trephine openings, the Gigli saw passed over it, and the bone divided on the bevel. With elevators the bone flap is now carefully raised and its base fractured, care being taken not to separate the soft parts of the scalp from the surface of the bone. The bone flap is then surrounded with several layers of gauze wrung out in saline solution and any small, sharp edges at its base removed with rongeurs.

The exposed dura is now carefully examined and palpated, and all oozing from the dura and bone edges controlled by pressure with hot gauze sponges.

If the dura is to be incised, meningeal vessels are either tied by means of fine silk ligatures passed on a fine needle, or the vessels are caught with mosquito forceps as they are cut, and are later ligated. For the incision of the dura a fine scalpel should be used; the outer and inner layers of the dura must be separately divided. If care be taken, the arachnoid is left uninjured at this time. I generally make the base of the dural flap away from the base of the bone flap and about one centimeter from the edges of the cut bone. The direction and size of the incisions in the dura will depend upon the conditions and will often have to be varied. If there is marked protrusion of the brain, it is advisable to decrease the intracranial pressure by lumbar puncture, or better, by aspiration of a ventricle before the dural flap is made.

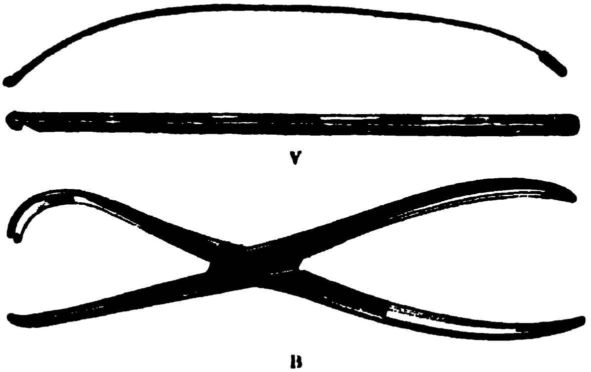

Fig. 20.—A—Grooved Guide and Dural Protector for Gigli Saw. B—Krause's Flap Forceps.

When the dura has been cut, extreme care must be taken that the exposed cortex is not injured, and for this purpose it must be covered by a moist gauze sponge. If aspiration of the ventricles has not sufficiently decreased the bulging of the brain, it is often advisable to do a subtemporal decompression. **One cannot emphasize too strongly the importance of careful work at this stage.** Not a few operations were failures because the operator did not relieve the high intracranial pressure before he opened the dura.

As soon as the surgeon is ready to close the dural incision he must determine whether the protrusion of the brain will prevent the approximation of the edges of the dura. The brain tissue must be handled with the greatest gentleness, and if it cannot be held back sufficiently the bulging must be reduced by means of lumbar or ventricular puncture. If the operation has been done on the right side, one has often to open the dura in the subtemporal region and allow the brain to protrude in this location so that the original dural incision may be closed. The success of the operator will depend upon his patience and skill. The dura can often be closed in cases where at first the suture seemed impossible. If the dura cannot be closed, the exposed brain should be carefully covered with a piece of Cargile membrane, or a piece of fascia may be taken from the patient's thigh and a plastic operation done.

If the protrusion of the brain is so great that the bone flap cannot be replaced, it is better to remove the bone from the flap and then unite the edges of the soft tissues of the scalp. The deeper layers of the scalp must be united with fine catgut sutures, and the skin edges with fine silk. The skin sutures must be placed very near together and care taken that the skin edges are well approximated. The resulting scar will be hardly noticeable. Finally, the hemostatic sutures are cut and removed and a firm compression bandage applied.

The first dressing should be done after one week, unless there are special indications for an earlier change of bandages.

Dangers and Difficulties in the Making of Osteoplastic Flaps.—Great care must be taken that the dura is not injured when an osteoplastic flap is made. I believe that injury to the dura is much more apt to occur when rotatory saws and fraises are used instead of bone cutting forceps. No matter what type of instrument is used to cut the osteoplastic flap, especial care must be taken in the following regions: near the median line so as to avoid the longitudinal sinus; near the superior curved line of the occipital bone under which runs the transverse sinus; in the frontal region to avoid the frontal sinus. The dura over the venous sinuses is often very thin and easily torn, and the sinuses sometimes run in deep grooves in the bone. The grooves for the anterior and posterior branches of the middle meningeal artery are often very deep, so that the artery almost runs in a bony canal; unless care is taken it may be injured when the flap is being cut.

Sometimes large emissary veins run in the cranial bones, especially in the parieto-occipital regions, and considerable bleeding may occur when they are injured. This bleeding can always be temporarily controlled by filling the channel which has been cut in the bone with Horsley wax.

Before an osteoplastic flap is made in the frontal region the size and shape of the frontal sinuses must have been determined from X ray plates. In this way injury to the frontal sinuses can with certainty be avoided. If an opening into a part of a frontal sinus has been made, the opening should at once be plugged with wax.

There are seldom any difficulties in making an osteoplastic flap, no matter how thick the cranial bones may be. In most instances the base of the flap is made in the temporal region because the bone is thinnest in that region and the base of the flap most easily fractured where the bone is thin.

When the bone flap is fractured at its base and turned back the surgeon must be careful that the soft tissues of the scalp are not separated too much from the bone lest necrosis result.

When the bone flap is returned into its place care must be taken that it is properly replaced and that the bone does not rest upon the dura. If the Gigli saw cut has not been made oblique enough and the bone flap rests upon the dura it is advisable to drill a few holes in the flap and surrounding bone and to fix the flap with a few catgut sutures.

The bone flap must be kept well in position by a firm compression bandage. If a firm bandage has not been applied the flap may be raised from its place by a collection of blood, and bony union may thus be interfered with.

Postoperative Complications.—If the asepsis has been perfect and the wound has been properly sutured, healing should be complete in from 3 to 5 days. I am accustomed to leave the sutures undisturbed for at least a week unless special indications for their removal have arisen. A firm supporting bandage should be worn for at least 2 weeks so as to allow an osteoplastic flap to become fairly well united, or, if there is a cerebral hernia, to allow the wound in the scalp to be well healed so that no separation of the wound edges can occur. In patients with unclosed dura, in the presence of raised intracranial pressure, separation of the edges of the wound may occur unless a firm bandage is worn for several weeks, and I know of several instances in which a primarily healed wound was left unsupported too early with a resulting separation of the wound edges and formation of a hernia of the brain.

MARGINAL NECROSIS OF THE BONE.—If the periosteum has been too much separated from the bone of an osteoplastic flap, marginal necrosis of the bone may occur. Sinuses form after a few weeks, a discharge persists, and with a probe bare bone is to be felt. I have had this occur in one of my patients, and it required many weeks for the sequestra to become separated. Fortunately the dura had been well closed in the patient so that no infection of the meninges occurred. In the making of osteoplastic flaps the operator cannot be too careful that he or his assistant does not loosen the bone from the periosteum by too rough manipulations.

HEMORRHAGE UNDER THE BONE FLAP.—This has occurred twice in my experience. After all operations a slight amount of blood, insufficient to cause any symptoms, collects under the flaps, but, if the hemostasis has been perfect, and an appropriate dressing has been applied after the operation is completed, the amount of bleeding should be negligible. In spite of these precautions I have twice had to reopen a cranial wound in order to give exit to a large amount of blood which had caused pressure symptoms. Both patients recovered.

If the dressings have not been well applied, have become loosened, or have been removed too early, serum may collect between the dura and the bone flap and raise the latter from its place. If this condition of affairs is found at the first dressing, the skin of the scalp along the suture line should be painted with tincture of iodin and a small opening in the suture line made with a probe. Pressure on the scalp and the bone flap will then cause the bloody serum to escape. No drain should be inserted, but only a firm compressive dressing applied. If such a collection of fluid has occurred after an operation in which the dura was left open, it is advisable to do nothing for several weeks excepting to see to it that the dressings are firmly applied over the field of operation.

LEAKAGE OF CEREBROSPINAL FLUID.—If the wound has been carefully sutured, if healing has been good, and if the bandages have been well applied, leakage of cerebrospinal fluid should rarely occur. Such a leakage is a very unpleasant complication and is very dangerous on account of the danger of infection of the meninges. The amount of fluid that escapes may be very large, wetting the bandages and the bed clothes and necessitating a frequent change of dressings. If there is leakage, the dressings must be changed under the most rigid aseptic precautions. As soon as the dressings are removed the entire suture line, and especially the small fistulous opening, must be thoroughly painted with tincture of iodin, and a firm bandage applied. The iodin keeps the skin sterile and therefore lessens the danger of infection traveling inward to the meninges. In spite of every precaution, if the leakage persists for a number of weeks, infection of the meninges will occur. I have not seen a case with death from this complication, but I know of several instances in the experience of colleagues. For this reason I cannot see any possible advantage in the operation of drainage of the cisterna magna for meningitis, which has been recently proposed.

SUBCUTANEOUS COLLECTIONS OF CEREBROSPINAL FLUID. This may occur after suboccipital decompressive operations. Such a collection of fluid may form a swelling of considerable size in the suboccipital region, and be very annoying to the patients. Such collections of fluid may be emptied by aspiration, but the fluid usually collects again. In one instance I have transplanted a piece of bone removed from another patient, and by this means have prevented the fluid from reaching the subcutaneous tissues.

PROLAPSE OF BRAIN TISSUE. This has been known to occur, not only after operations for brain abscess, but also after operations for disease accompanied by increased intracranial pressure in which the wound edges have separated. Prolapse of the brain is always a serious wound complication; after it has once occurred the prolapse is apt to increase in size. The entire prolapse must be painted with tincture of iodin and a well fitting bandage applied. In some instances the prolapsed brain tissue will become necrotic and have to be excised; in other cases the brain tissue will gradually shrink and the prolapse be reduced in size, covered by granulations, and the skin will grow over it.

WOUND INFECTION. Wound infection is always a most serious complication and must be treated according to general surgical principles. A cranial operation should never be performed unless the surgeon is certain of the condition of the operating room and all that it contains.

CRANIECTOMY

When a region of the brain is to be exposed by the removal of part of the bony skull, the hemostatic suture is first applied and a flap of the soft parts then turned down. One or two trephine openings are then made, and the bone rongeured away. There may be profuse bleeding from the bone, but this is always easily controlled by rubbing wax into the bleeding spots. If the operator is removing bone in the neighborhood of one of the venous sinuses he must frequently pass a small periosteal elevator between the bone and the dura in order to ascertain that the dura can be separated from the bone.

SUBOCCIPITAL CRANIOTOMY

When the subtentorial region is to be exposed, it is generally advisable to do a bilateral operation, and I shall therefore describe the bilateral operation in what follows. Whenever a unilateral operation is to be done, only half of the procedure to be described has to be done, and an omega-shaped flap may be made. The indications for the unilateral operation are few, mainly for operations for cerebellar abscess or cyst.

Surgical Anatomy. A thorough knowledge of the anatomy of the suboccipital region is necessary for the successful accomplishment of an operation in the suboccipital region.

Upon the surface of the skull the region to be considered extends from a short distance above the superior curved lines of the occipital bone above to the margin of the foramen magnum below, and from the posterior margin of the external auditory meatus on one side to that of the other. This entire region is within the possible area of operation. In tumors of the upper surface of the cerebellum it may be necessary to remove the occipital bone for 3 to 5 cm. above the superior curved line, in order that the tentorium can be retracted and the upper surface of the cerebellum freely exposed. Where the lesion is situated in the cerebellopontine angle it is always necessary to have the opening in the skull extend well into the body of the mastoid process.

The integument over this region is very thick, especially in the suboccipital region, where a large number of muscles are attached. The soft parts are freely movable over both mastoid regions and over the upper part of the occipital bone. Laterally 1 to 2 cm. below the level of the external occipital protuberance thick muscles are inserted into the bone. The periosteum can be easily separated from the bone down to the level of the muscular and ligamentous attachments. Below this level the muscles have to be cut from the bone with scalpel or scissors. About 1 cm. from the margin of the foramen magnum the muscular attachment to the bone ceases, and the periosteum can again be stripped from the bone with ease. When this region is reached the operator knows that he is near the foramen.

The blood supply of the skin and soft parts is derived from the occipital, posterior auricular, and posterior branches of the temporal arteries on both sides. The operator may expect to meet with 2 large vessels in the mastoid region (Fig. 21). These lie about 3 cm. apart, the one about 1 cm. above, the other about 2 cm. below the level of the external auditory meatus. A large branch of the occipital artery perforates and supplies the muscles in the suboccipital region of each side; this vessel is almost always injured when the muscles are being separated from the bone.

In children the occipital bone is never very thick, but in adults the greater part of it may be almost 1 cm. in thickness. The thinnest part of the occipital bone lies laterally below the uppermost level of muscular attachments. This part of the bone should first be removed and the trephine openings should be made in this location.

From the standpoint of hemorrhage most of the vessels in the bone are of insignificant size. In the region of the masto-occipital suture, however, one or more large emissary veins may be encountered. These veins, which empty into the lateral sinus, may be of large size, and the bleeding from them very profuse.

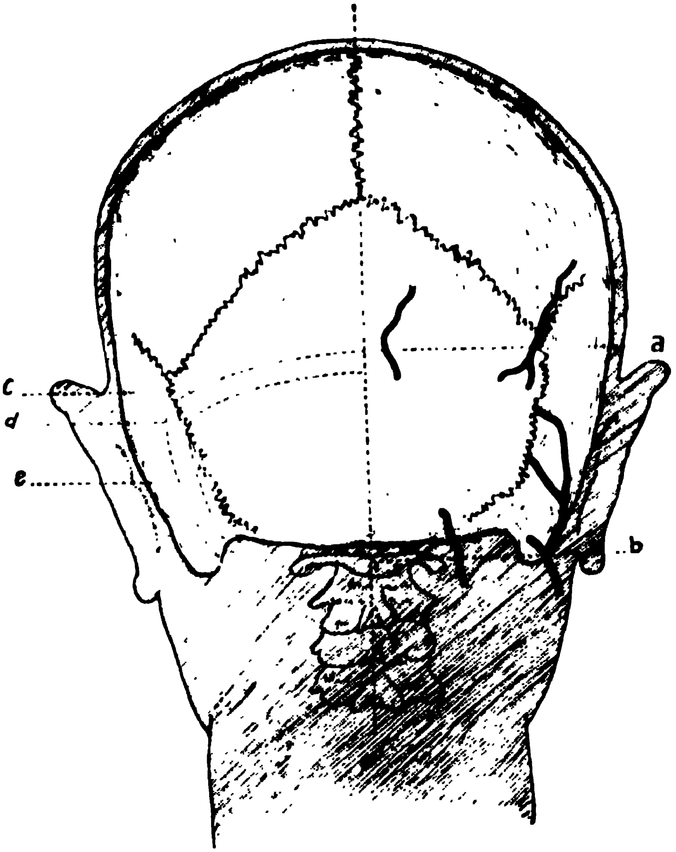

FIG. 21.—THE MOST IMPORTANT BLOOD-VESSELS IN THE SUBOCCIPITAL REGION. A external occipital protuberance; b arch of atlas, c, d, e transverse sinus, knee of sinus, lateral sinus.

A smaller vein which may cause troublesome bleeding runs in the substance of the occipital bone near the knee of the transverse sinus.

The exact course of the transverse sinus will be found to correspond to a line drawn from the external occipital protuberance to the base of the mastoid process or to the depression which corresponds to the parietomastoid suture (Kocher): the bend or knee of the sinus lies in this latter region, from which the lateral sinus runs vertically downward underneath the middle of the mastoid process. At the bend or knee the sinus is sometimes joined by a small vein from the lateral edge of the cerebellar hemisphere. Several small veins frequently

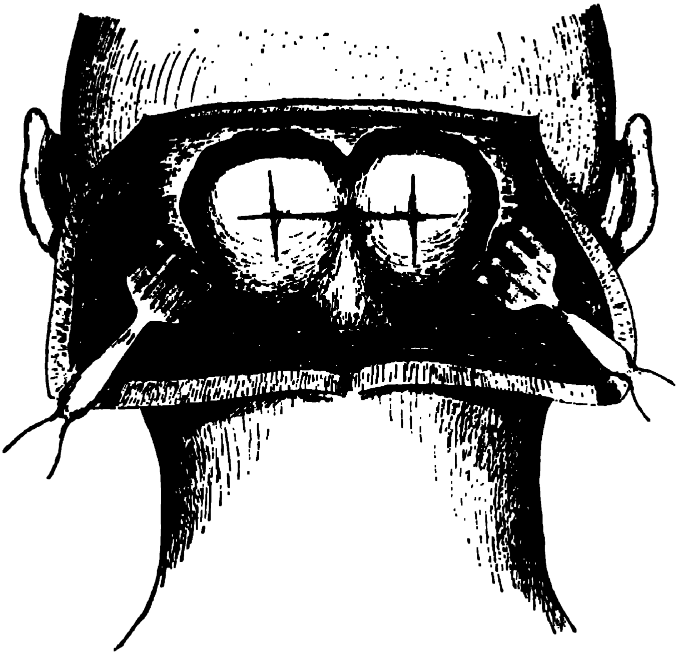

FIG. 22.—POSTERIOR SUBARACHNOID CISTERN.

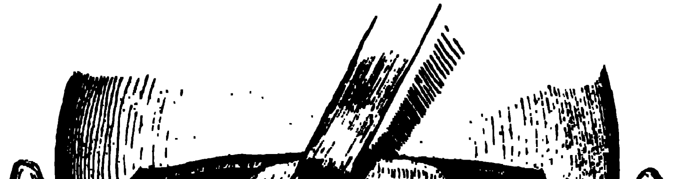

FIG. 23.—EXPOSURE OF THE FACIAL AND AUDITORY NERVES IN THE LEFT CEREBELLOPONTINE ANGLE.

run from the upper surface of each hemisphere to the transverse sinus near the median line. These veins may be injured when the dura is incised or they may be torn when the dura is retracted. In either case a disturbing hemorrhage in the lateral recess of the posterior fossa takes place. Mention must be made of a small but important sinus which runs around the edge of the foramen magnum. This "marginal" sinus is mentioned only by Borchard and Krause.

When the dura is turned back without injury to the arachnoid a collection of fluid will usually be seen underneath the arachnoid between and below the cerebellar hemispheres. This is the "posterior cistern," which has been mistaken for a cyst by some operators (Fig. 22). Laterally, fairly well forward, there are "lateral cisterns."

The cerebellar hemispheres fit snugly into the bony walls of the posterior fossa, so that the lateral aspects and the cerebellopontine angle can only be exposed when the principle of "dislocation" is applied. When the cerebellar hemisphere is gradually dislocated toward the median line more and more of the petrous portion of the temporal bone will become visible. In the depth will be seen the internal auditory meatus with the facial and auditory nerves entering it (Fig. 23). The facial nerve lies in front and somewhat deeper than the eighth nerve. Just in front of the nerves, and somewhat more deeply, one may often see a few small veins which run from the lateral edge of each hemisphere to the superior petrosal sinus. These veins may cause troublesome oozing of blood when a tumor is being removed from the cerebellopontine angle.

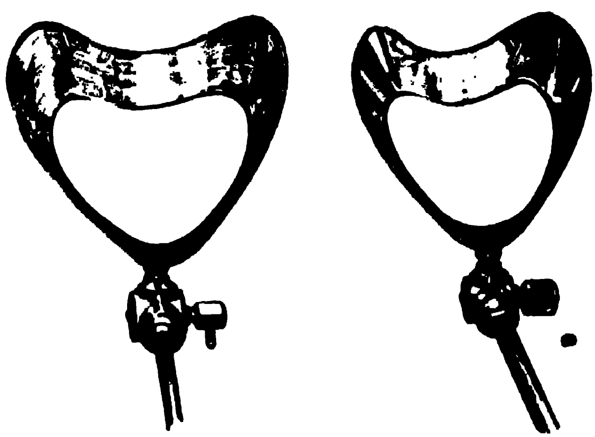
FIG. 24. HEAD RESTS FOR SUBOCCIPITAL CRANIOTOMY.

Position of the Patient. For a bilateral occipital craniotomy the position of the patient is of great importance, because the patient has to lie flat on the abdomen with the head flexed upon the chest. The field of operation must be well exposed and the chest must be raised from the operating table so that respiration is not interfered with. For this purpose Cushing has a special "outrigger," and Frazier has a special table, but I use a simple head rest, which can be attached to any operating table, and which is a modification (Fig. 24) of Hartley's head rests. The chest is raised from the table by means of large head pillows, which are placed under each shoulder (Figs. 25 and 26).

The Anesthesia.—The anesthetic is best given by means of intratracheal insufflation, but it can also be given with an open mask, the anesthetic being sprayed upon the mask with an ordinary hand bulb atomizer.

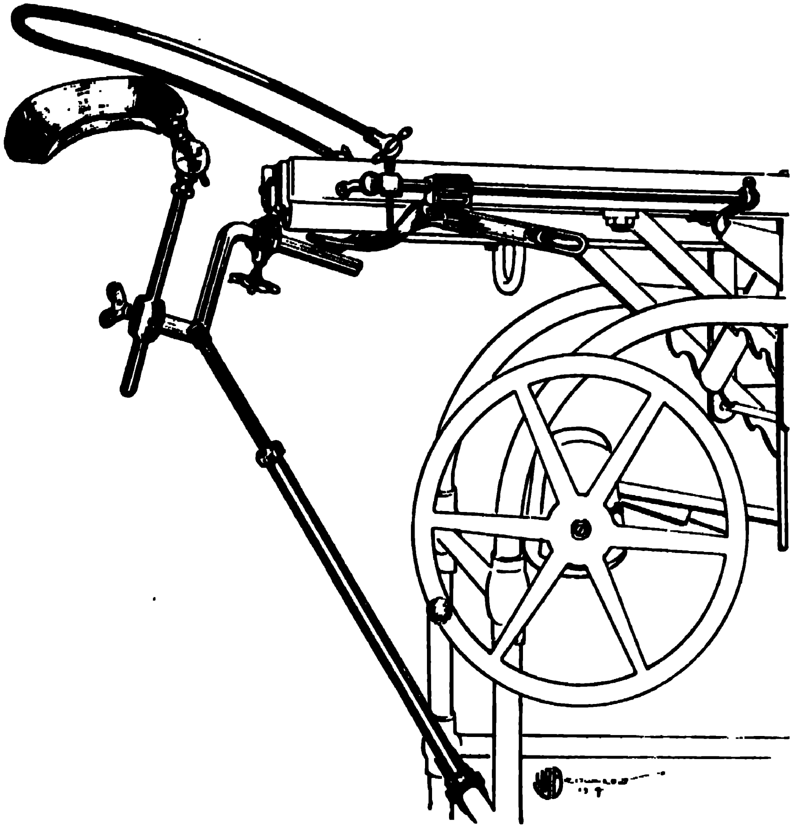

Fig. 25.—Operating Table and Head Rests in Position.

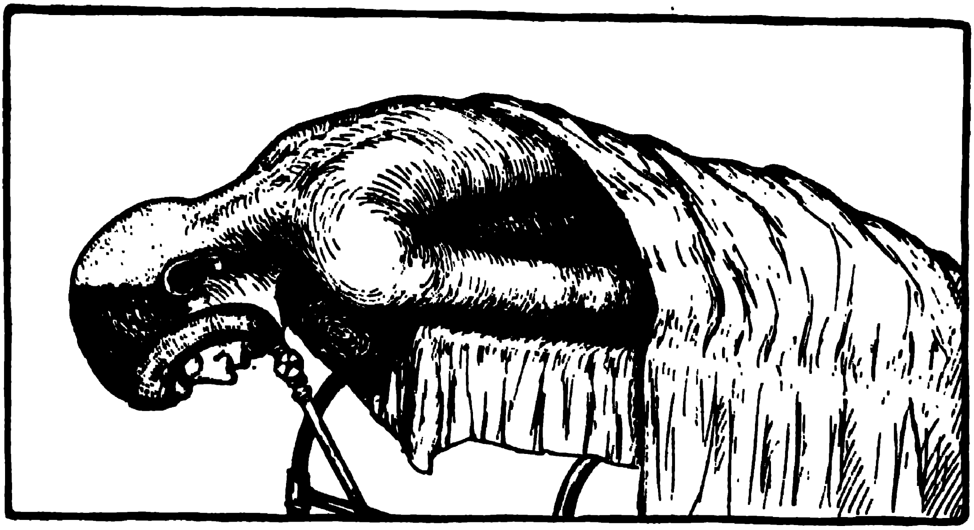

Fig. 26.—Position of Patient on Table for Suboccipital Craniotomy.

THE OPERATION (FIGS. 27, 28, 29)

A curved incision is made from the base of one mastoid process to the other, and a vertical incision in the median line to the level of the spine of the first cervical vertebra. The transverse incision should penetrate only the skin; the skin should be dissected from the fascia for a distance of two centimeters, and the fascia and periosteum divided at this level. The vertical incision is then made and deepened between the muscles until the spine of the atlas is exposed. The 2 right angled flaps thus formed are separated from the bone by means of a sharp raspatory, the muscular attachments to the bone being divided close to the bone by means of heavy scissors curved on the flat. In dividing and separating the muscles near the mastoid processes one must be on the lookout for several large muscular branches of the occipital arteries, and as the margin of the foramen magnum is approached the operator must keep very close to the bone so as to avoid injuring the marginal sinus.

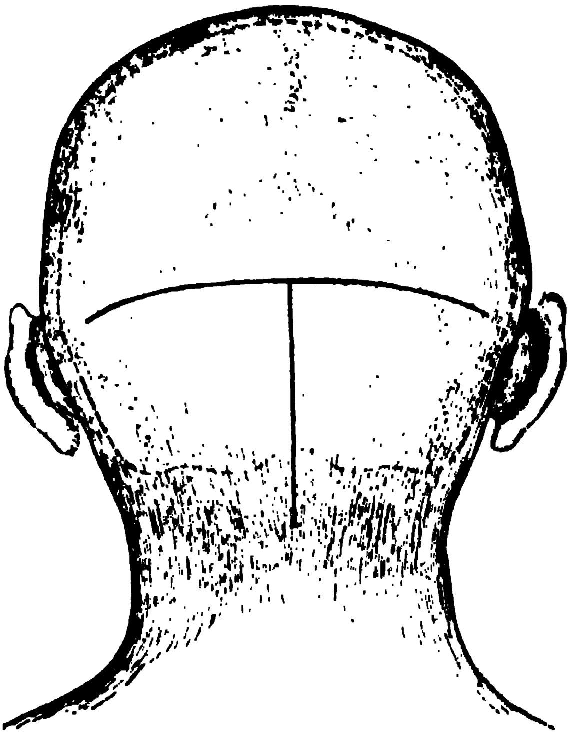

FIG. 27.—INCISION FOR BILATERAL SUBOCCIPITAL CRANIOTOMY.

The 2 right-angled flaps thus formed are retracted downward and outward, and with a trephine 2 openings are made in the occipital bone. These openings are made several centimeters below the superior curved line and several centimeters from the median line. The bone in this region is generally very thin, and an instrument, such as the drill of Hudson, will perforate the bone very quickly and will not lock. The 2 openings are now enlarged in all directions with variously sized rongeurs. Outward the bone is removed well into the mastoid process on each side up to the point where the mastoid is very thick. As the operator approaches the median line it is advisable to introduce a grooved director underneath the bone from one opening to that of the other side in order to act as a guard for the dura.

Downward the bone is removed into the foramen magnum, the bone becoming thicker as the margin of the foramen is reached. At least 1 to 2 in. of the foraminal margin must be removed; this can usually be accomplished without difficulty. Care must be taken not to injure or make pressure upon the dura and medulla underneath.

If the operation is to be done in 2 stages, the wound is thoroughly washed out and all fragments of bone removed. The flaps are then turned up and carefully sutured into place. This suture must include: (1) suture of the muscles in the median line in several layers; (2) union of the upper edges of the fascia to the fascia on the occipital bone; (3) suture of the skin. A large compressive dressing is then applied.

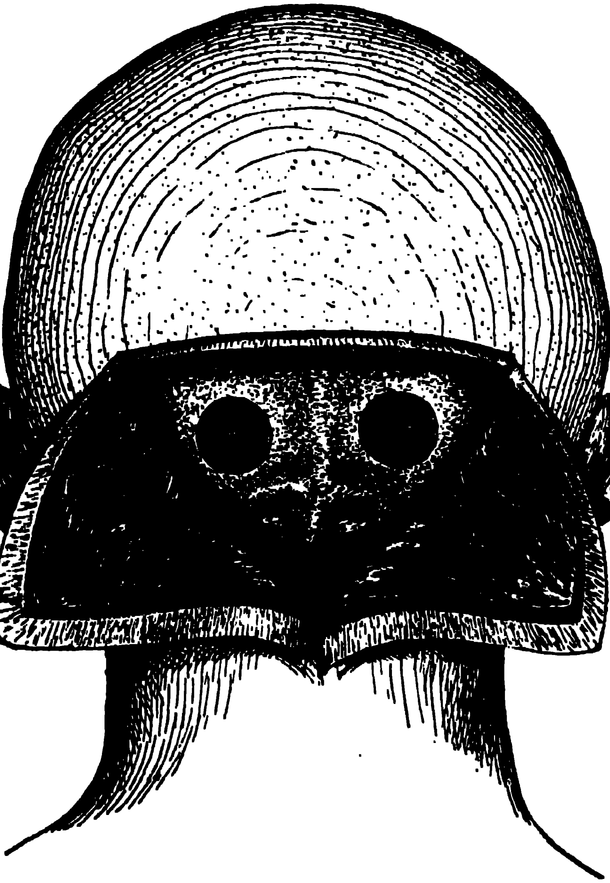

FIG. 28.—BILATERAL SUBOCCIPITAL CRANIOTOMY. Buttons of bone removed after reflexion of scalp and muscles.

If the dura is to be opened at the first operation, this is accomplished in the following manner: A transverse incision is carefully made through the dura on each side of the median line over the greatest prominence of the cerebellar hemispheres; this is enlarged laterally and toward the median line by cutting on a grooved director; finally, a grooved director is pushed under the dura in the median line and the dura incised across the median line, the occipital sinus being caught with mosquito artery forceps as it is cut if there is any bleeding. If necessary, vertical incisions are made upward and downward over the middle of each hemisphere, care being taken not to injure the transverse sinus above (Fig. 29).

If the herniation of one or both cerebellar hemispheres is so extreme that there is danger of laceration of the brain tissue, it is advisable to remove bone above until a small part of the dura over one occipital lobe is exposed, and then to empty fluid from the ventricles by aspiration of one posterior horn. In spite of the fact that part of the foraminal margin has been removed, I believe it is not safe to do a lumbar puncture at this time unless the dura has been widely opened.

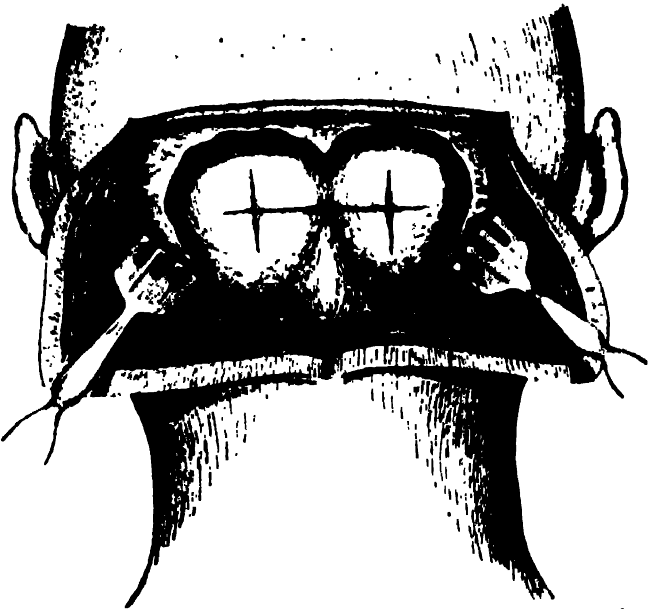
FIG. 29. BILATERAL SUBOCCIPITAL CRANIOTOMY. All of the bone has been removed and the location of the dural incisions indicated.

After the intradural manipulations have been ended the dura should be closed (unless decompression or drainage is necessary), followed by closure of the soft parts as above described.

Unilateral Suboccipital Craniotomy. In the large majority of instances it is preferable to do a bilateral operation. When a cerebellar abscess is to be opened, however, the bone need only be taken away on one side, and this may be accomplished by turning down a flap of soft tissues in one suboccipital region and removing as much bone as is necessary in order to aspirate the affected hemisphere. Wherever the cerebellum or a lateral recess has to be explored and palpated a bilateral removal of bone is necessary in order to permit of dislocation of the hemispheres to the one or the other side.

Other Methods of Performing Suboccipital Craniotomy.—Although we advise strongly against osteoplastic flap operations in this region, some surgeons still favor the preservation of the bone. A bone flap can be cut with Hudson or Dahlgren forceps after making two trephine openings, one each at the upper outer angle of the bone flap that is to be made. Great care must be taken when the bone is cut across the median line, and the vertical cuts must extend into the foramen magnum. If a large mastoid emissary is injured, it may be difficult to stop the bleeding until much blood has been lost.

Dangers and Difficulties of the Operation.—The hemorrhage from the soft parts can always be easily controlled with artery clamps, but oozing from numerous small vessels in the bone is sometimes very troublesome, numerous small veins from the diploë bleeding constantly. Sometimes the bleeding can be controlled with Horsley wax, at other times by means of gauze pads wrung out in hot saline solution.

If a large mastoid vein is injured when the bone is being rongeured away, the opening must either be filled with wax or a small wooden plug, of which a number should be on hand, is hammered into the opening.

Injury of a transverse sinus should not occur, but if it has been injured ligatures must be applied to it in the manner described in another section. (See Technical Details of Craniotomy.) The best preventive against injury of the transverse sinus is to have the sinus well exposed, and for this purpose the bone must always be removed in the upward direction until the sinus is well exposed on both sides. When a 2-stage operation is to be done it is a good plan to place one or two sutures of black silk below the sinuses as a guide for the second operation.

The bleeding from a large marginal sinus is sometimes so active and so difficult to control that it is better to introduce a packing and conclude the operation at this stage.

The bleeding from the occipital bone is sometimes so profuse that the operation has to be terminated for the time being before all of the bone has been removed. Sometimes the entire surface of the bone seems to be oozing blood, and it is impossible to control the bleeding by means of pressure.

The soft parts must always be well freed from the bone down to the foramen magnum before trephining is begun. The inexperienced operator is very apt to make his transverse incision too high so that too much of the occipital bone is laid bare, and to fail to make the vertical incision long enough, so that the margin of the foramen and the posterior arch of the atlas are not well exposed. If the exposure of the lower part of the occipital bone is not good, much trouble will be experienced in removing the bone into the foramen magnum.

Sometimes it is unnecessary to remove the bone as widely on the side opposite to that of the lesion, but if the operator expects to have to dislocate the cerebellum, as in the exposure of a tumor in the cerebellopontine angle, a large bony defect must be made on both sides.

In several cases in which the bulging of the cerebellar hemispheres was very great I have performed a puncture of the corpus callosum so as to relieve the tension. I believe that this is as simple a procedure as exposure of an occipital lobe and aspiration of the ventricle.

CEREBRAL DECOMPRESSION

VARIOUS METHODS FOR CEREBRAL AND CEREBELLAR DECOMPRESSION

The brain in its dural covering is inclosed in a cavity with unyielding wall, the cranial cavity. When an increase of intracranial pressure occurs, no matter whether it is due to a new growth, an increase of fluid in the ventricles, an edema of the brain tissue, or intracranial hemorrhage, the soft brain tissue must be compressed. In infants and young children, in whom the bones of the skull are soft and not united, the cranial bones will often yield to the pressure and the skull become enlarged. This is nature's decompressive effort. Excepting in rare instances, such a separation of the cranial bones cannot occur in adults; the brain tissue becomes compressed, its function is interfered with, and the well-known general and local symptoms of increased intracranial tension appear.

I believe that in our operations for cerebral and cerebellar decompression we have given too much thought to the method of the operation and too little attention to the principles upon which such decompression should be based. As I have shown elsewhere, we must ask ourselves, in each patient in whom a relief of cranial pressure is desirable, two questions, first, is a decompression necessary; and, second, how shall we do the decompression so that the direction in which the dislocated brain tissue will travel shall not be one that will interfere with important nerve tracts? Is it not natural that if we do a decompressive craniotomy over the affected area, let us say the left face and arm area, that a speech disturbance is sure to follow? Is it right to do a right subtemporal decompression for a midbrain tumor or a tumor in one of the central ganglia on the left side? Such a procedure will often be followed by new symptoms in spite of the fact that we have relieved the headache, the vomiting, and the swelling of the optic discs.

More or less internal hydrocephalus occurs in the large majority of brain tumors, and the examination of the brains of those upon whom a decompressive operation has been performed before death shows that the distended ventricle caused much of the hernial protrusion, was distorted, and dragged toward the opening in the skull. Is it not strange, therefore, that in the attempt to relieve intracranial tension so much attention has been paid to the craniotomy and so little to the efforts to permanently relieve the internal hydrocephalus? In many cases of brain tumor a puncture of the corpus callosum should relieve the general brain symptoms which are due to a great extent to the accompanying internal hydrocephalus, and leave the patient free from a deforming hernia, which is less or more marked, depending upon the degree of intracranial pressure.

Thus a subtemporal decompression will seldom do good when the tumor is in the posterior cranial fossa or in the midbrain. A puncture of the corpus callosum may relieve the general symptoms of a subtentorial growth, for they are often due to a distention of the ventricles, and a bilateral subtemporal decompression is more rational for a midbrain tumor than a unilateral operation, although the permanent drainage of the ventricles through the corpus callosum is often better. In short, I believe that in every instance of raised intracranial pressure in which a dilatation of the ventricles is probable a callosal puncture should be done first, followed at once or later by a decompressive craniotomy, and since I have held this view, and have carried it into effect, I have had much better results from my decompressive operations.

The surgeon will often be called upon to perform an operation for the temporary relief of this increase of intracranial pressure either as an adjunct to other methods of procedure or for the direct relief of headache, vomiting, and optic neuritis. In the majority of cases the decompression is only a palliative measure, although sometimes it is curative.

INDICATIONS AND CONTRA-INDICATIONS

The main indications for and contra-indications to one of the decompressive procedures are the following:

1. **In expanding lesions of the brain, where localization is impossible,** the sufferings of the patient are very great, and the danger of blindness from the optic neuritis imminent. In these patients the decompressive operation may not only alleviate the symptoms, freeing the patient from the agonizing headache and vomiting, and causing the optic neuritis to retrograde or subside entirely; it may also tide the patient over until localizing signs and symptoms have appeared. No rules can be laid down as to the time when operative interference is indicated, each case having to be considered for itself, but increasing optic neuritis with diminishing visual acuity and beginning contraction of the visual fields demands a decompressive operation.

2. **When the lesion has been localized, but from its nature or location cannot be removed, and is causing marked increase or intracranial pressure.** In this category are to be placed patients with infiltrating tumors found at operation, many deeply placed subcortical growths, some tumors of the basal ganglia, and those which cause direct pressure upon the optic tracts and optic chiasm (sellar decompression).

3. **When there are extensive paralyses** from invasion of important tracts, or when the patient is already blind but has few or no other symptoms, *no decompressive measure* should be attempted, unless the patient's few remaining days may be made more comfortable by the interference. Many vain attempts have been made to restore some degree of vision in those already blind by means of one of the decompressive methods, but these have uniformly failed of success. When vision has once been lost it can never be restored; an advanced optic neuritis may go on to complete optic atrophy and blindness in spite of a decompressive operation. The blindness which follows pressure upon the optic chiasm, the end stage of a bitemporal hemianopsia, may, however, partially

disappear after an operation upon the hypophysis or a sellar decompression (q. v.).

4. **When the symptoms are due to a congenital or obstructive hydrocephalus,** only those decompressive measures are justified which directly remove or drain off the fluid from the ventricles (lumbar puncture, aspiration of the ventricles, puncture of the corpus callosum, other methods of auto drainage of the ventricles). A large cranial defect with the resultant cerebral protrusion will not lessen the cerebral tension, but will only allow the ventricle to become more distended.

5. **Acute Intracranial Conditions Associated with Edema of the Brain Tissue.**—A decompressive operation is often necessary in certain acute intracranial conditions associated with edema of the brain tissue. In bursting fractures of the base or vault of the cranium a cerebral decompression will often relieve the swelling of the brain tissue. Decompression is useless in the edema of the brain and optic neuritis which occur in nephritis.

6. **Epilepsy.**—Kocher recommended a decompressive craniotomy over the motor area in many cases of epilepsy, but the operation has been of value in few, if any, patients.

The methods employed for cerebral decompression are: (1) lumbar puncture; (2) ventricular puncture; (3) puncture of the corpus callosum; (4) decompressive craniotomy; (5) sellar decompression.

1. LUMBAR PUNCTURE AS A DECOMPRESSIVE METHOD

Repeated lumbar punctures have sometimes had a beneficial effect upon the symptoms of chronic hydrocephalus, congenital or acquired. For this purpose the lumbar puncture should be done every four to six days, 30 to 50 c. c. of fluid being removed each time. Personally I have never succeeded in permanently improving a patient with chronic hydrocephalus by repeated lumbar punctures.

While lumbar puncture may do some good in obstructive hydrocephalus due to posterior basic meningitis, its chief value is in that form of distention that occurs with intracranial tumors. When, in the course of an operation for tumor or abscess of the cerebral hemispheres, the intracranial pressure is found to be very high, it is often advisable to do a lumbar puncture before the dura is opened and thus prevent too great a protrusion of brain tissue. More often the ventricles are aspirated for this purpose. Similarly, lumbar puncture is often useful at the end of an operation when the intracranial pressure must be lowered before the dura can be closed by suture.

Spinal puncture should never be done **when the tumor lies under the tentorium,** unless a wide opening has already been made in the occipital bones, on account of the danger of herniation of the cerebellum into the foramen magnum and sudden medullary death.

2. PUNCTURE OF THE VENTRICLE AS A DECOMPRESSIVE METHOD

Puncture of the ventricle is useful only in the cases in which the ventricles are distended with fluid, and is a valuable aid during operations upon the brain in the presence of increased intracranial pressure. It is often used to diminish the tension before the dura is opened, or to allow of the closure of the dura at the conclusion of the operation.

In infants with open fontanels the lateral ventricles can be reached through the lateral angle of the anterior fontanel (see Exploratory Puncture of the Brain).

During the course of an intracranial operation, when the dura is very tense, the ventricle may be punctured before the dura is opened (see the various intracranial operations in a succeeding section). The ventricle can usually be reached from some part of the dura that has been exposed by the opening made in the skull, but the operator must have a good knowledge of the location of the lateral ventricles. Through a subtemporal opening the ventricle can usually be reached by passing the needle directly inward and slightly backward from the posterior part of the opening to a depth of 5 to 6 cm. When an occipital opening has been made the needle must be passed forward and downward. In frontal operations the needle is passed downward and backward about 2 cm. from the median line. The distance from the surface of the dura or brain to the ventricle will vary with the amount of distention of the ventricles. At the close of a brain operation it is often impossible to suture the dura until the ventricle has been emptied and the protruding brain tissue thus made to recede.

3. PUNCTURE OF THE CORPUS CALLOSUM

This operation was devised by Anton and von Bramann in 1908 as a decompressive method in cases of increased intracranial pressure due to distention of the ventricles. The object of the operation is to make a permanent opening in the anterior part of the corpus callosum, by means of which communication is established between the lateral ventricle and the subarachnoid space over the convexity of the hemispheres (Fig. 30).

Puncture of the corpus callosum may be tried in the following conditions: (1) in the treatment of congenital or acquired chronic hydrocephalus, to create a new path for the course of the ventricular fluid to the subarachnoid space; (2) in the treatment of obstructive and secondary distention of the ventricles due to tumor in the posterior fossa or in the midbrain. It is often the only palliative method at our command for the treatment of midbrain tumors; (3) to lessen the general intracranial pressure before or during the course of operations for brain tumor.

In infants the operation may be done through the lateral part of the anterior fontanel. In older children and adults I generally perform the operation in the following manner: Under local or, preferably, under general anesthesia an incision about 4 cm. in length is made in the scalp. The incision begins at a point about 1 to 2 cm. behind the coronary suture and 1 to 2 cm. from the median line, and is carried transversely outward. The soft parts of the scalp, including the periosteum, are retracted, and with an ordinary crown trephine a button of bone 2 cm. in diameter is removed. A small incision is then made in the dura, care being taken not to injure one of the numerous pial veins which exist in this location.

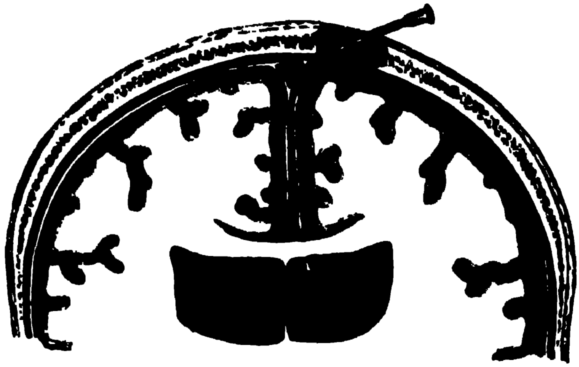
Fig. 30. Anatomy of Operation of Puncture of Corpus Callosum.

The field of operation is now ready for the introduction of the cannula. The cannula that I use is of a pattern devised by me. It is made of German silver so as to be flexible, and has a flexible stilet. The end is blunt and slightly bulbous, and there are several side openings in addition to the opening at the end (Fig. 31). The needle must be bent in a curve to accommodate itself to the path it is to follow. The cannula is passed under the dura through the slit that has been made and is pushed over the surface of the cortex toward the median line. When the falx has been reached the cannula is rotated and pushed forward so that it passes along the side of the falx cerebri until the slight resistance of the corpus callosum is felt. The stilet is now removed and the cannula pushed through the corpus callosum into the ventricle. Fluid at once escapes from the needle in a stream. By a rotating movement the tip of the cannula is now made to sweep forward and backward, thus tearing a hole about 1 cm. in length in the corpus callosum and allowing cerebrospinal fluid to escape by the side of the needle. The cannula is now withdrawn, the slit in the dura closed by a fine silk suture, the scalp wound carefully sutured and a tight dressing applied. If the cannula is passed in the proper direction there should never be any trouble in reaching the lateral ventricle about 6 cm. from the surface of the brain. The mistake which has sometimes been made is to point the tip of the cannula too far forward, so that the cannula passes in front of the genu of the corpus callosum. If all of the procedures are carefully carried out, a spot on the cortex selected which is free from large pial vessels, the tip of the cannula slightly manipulated when the corpus is reached so as to push aside the veins which run on the upper surface of the callosal body, no bleeding should occur, and the little operation accomplished without mishap. Anton

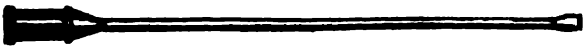
Fig. 31.—Author's Needle for Puncture of Corpus Callosum.

and von Brahmann have shown that the opening in the corpus callosum will remain patent on account of the fact that the pressure in the ventricles is higher than that in the general subarachnoid space. These authors have reported 53 operations without fatality, and I have performed more than 30 punctures of the corpus callosum and have never had a patient die from the operation.

Other operators report similar experiences. Anton and Brahmann have tried the method in the treatment of simple hydrocephalus, in distention of the ventricles due to tumor of the hypophysis, in obstructive hydrocephalus from tumors of the brain, especially those in the posterior fossa, and as a decompressive aid in operations upon the brain. They have seen great benefit from the procedure—subsidence of the optic neuritis, improvement in spasticities and paralyses, relief of headache, nausea, and vomiting. I have twice seen great improvement following the operation in inoperable midbrain tumors, and have found it a valuable aid during operations for brain tumor with marked intracranial tension. A number of patients with chronic hydrocephalus have been much improved by the operation, and this improvement has lasted for many months or years. In tumors of the midbrain, which usually cause dilatation of the third ventricle, puncture of the corpus callosum is the operation of choice.

4. DECOMPRESSIVE CRANIOTOMY

In this operation, a large defect in the skull and the dura is made, allowing a herniation of the brain through the opening, and causing by this means a relief of increased intracranial pressure. Decompressive operations are of great value in the palliative treatment of a large number of intracranial affections associated with an increase of intracranial pressure. The term decompressive trephining was first used by Jaboulay, while Broca and Maubrac were the first to speak of "cerebral decompression." This mode of treatment dates from the observations of Byrom Bramwell (1886), Annandale (1889), and Sahli (1891), and the method has been developed by the researches of Horsley, Keen, Bruns, Saenger, Jaboulay, Cushing, Frazier and Spiller, and many who followed them.

Decompressive craniotomy is eminently a palliative operation, and the surgeon should never forget that the method is not justified if the patient will not really derive benefit from it. Thus it would be manifestly wrong to do a decompressive operation upon a patient with an irremediable lesion, who has but a very short time of life left him, whose suffering is not great, and who is already blind. The growth of many brain tumors is a very slow one, and the patients remain alive for many years; it is to relieve the patients in whom a radical removal of the disease is impossible that the operation must be done. Paradoxical as it may seem, experience has shown that cerebral decompressive operations have conferred the greatest benefits upon those patients with intracranial growths who presented no localizing symptoms. Such individuals will often be entirely relieved of their symptoms for 1 to 5 years, and the periods of apparent complete relief are often so prolonged that the physician will remain in doubt as to the correctness of the original tumor diagnosis. While the disappearance of the headaches, the vomiting, the sensory and motor disturbances, and the subsidence of the optic neuritis are very frequent, there are not a few instances in which this improvement does not occur or in which the benefits from the operation are of very short duration. The symptoms may even become aggravated after the decompression. Thus I have seen a patient with general but no local symptoms develop extensive paralysis after the operation, the autopsy showing that a midbrain tumor had been operated upon. The symptoms due to a midbrain growth are apt to become much aggravated even after a bilateral decompression, and operative interference should be limited to a puncture of the corpus callosum. In proposing a decompressive operation the surgeon should always inform the family of the patient of the deforming hernia that may result.

Various methods of operation have been devised, but I firmly believe in the advisability of methods in which the hernia of the brain is supported by muscle, i. e. those operations which are done through muscular structures, such as the subtemporal and suboccipital operations recommended by Harvey Cushing. Furthermore, the decompression should, whenever possible, be performed over a silent area of the brain, so that no symptoms are produced by the interference with the functions of the protruding part of the brain. Some neurologists and surgeons (Horsley, Krause, Bruns, and others) hold the view that in localizable but irremovable tumors it is advisable to decompress directly over them. Such a procedure cannot be recommended. The degree of protrusion of the cortex is dependent upon the size of the expanding growth, the amount of ventricular distention, and the degree of intracranial pressure. On account of rupture of the cortex, of edema, and interference with the circulation in a cerebral hernia, the functions of the cortex are interfered with and hence a loss of function results. Thus a decompression over the motor area (which has often been recommended) may be followed by motor paralysis, a decompression over the speech area, by aphasia. Not a few unfortunates have been left aphasic after an intentional or unintended cerebral hernia over the motor speech area.

Whenever possible, therefore, the surgeon should close the dura and return the bone flap into place over the area he has explored or in which he has found an irremovable neoplasm (unless it happen to be a silent area), and accomplish the relief of pressure by a decompression over a silent area. I shall speak of this subject in greater detail in the chapter devoted to the surgical treatment of brain tumors.

Relief of pressure in the cerebral hemispheres can best be accomplished by a right or bilateral subtemporal operation (left-sided in left-handed individuals), relief of pressure upon the optic chiasm, by removal of the floor of the sella turcica; relief of subtentorial pressure, by a suboccipital decompression.

The full relief of pressure of an operation devised to allow of the increase of size of the intracranial contents can only be obtained by the removal of part of the bony skull and by incision or excision of an area of the dura. No advantage is gained by allowing the bone to remain in the bone flap. With marked protrusion of the brain the edges of the bone are very apt to cause a perforation of the soft tissues of the scalp.

Although the dura will yield somewhat after the bony support over it has been removed, and thus a certain amount of decompression will be obtained, it is always necessary to open the dura widely so as to allow the brain to protrude freely.

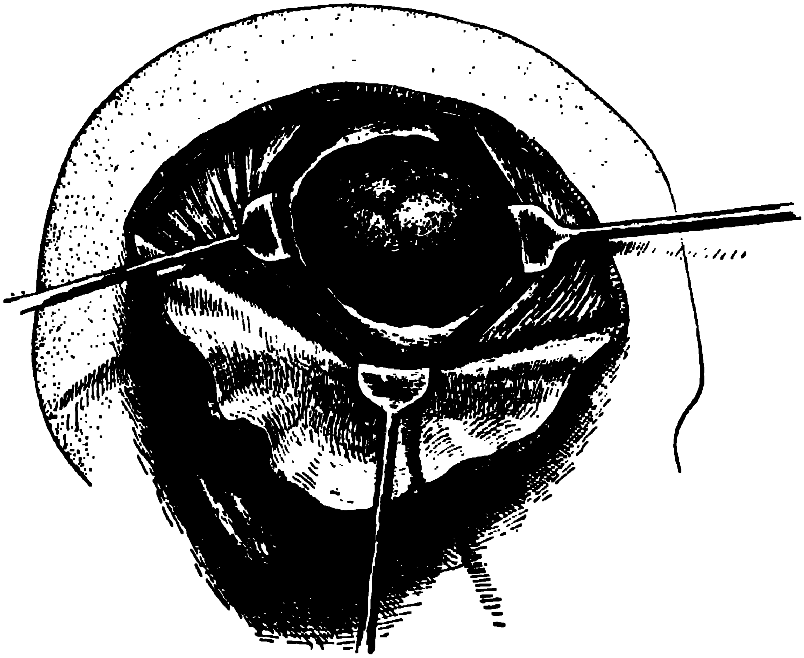

FIG. 32.—SUBTEMPORAL DECOMPRESSION.

Subtemporal Decompression.—Right (or left) subtemporal decompression is best performed according to the method of Cushing. A curved incision about 10 cm. long is made in the scalp about 5 cm. above the ear, and the scalp separated with the handle of the scalpel down to the attachment of the ear. The temporal fascia is then divided parallel to the muscle fibers and retracted, and the muscle fibers then separated, exposing the bone underneath. The periosteum is then pushed back until an area about 5 by 7 cm. is freed. In the center of this area a button of bone is removed with the trephine, and the bone then rongeured away on all sides until an opening roughly 5 by 7 cm. has been made. In the greater part of the subtemporal region the bone is very thin; as the mastoid is approached the thickness of the bone increases. After all oozing of blood has been controlled, radiating incisions are made in the dura, branches of the meningeal vessels being tied if necessary. If the intracranial tension is very high the cortex may protrude with such force that it ruptures. If the herniation of the cortex occurs too rapidly it is advisable to aspirate the lateral ventricle before making the wide opening of the dura. Cushing advises that the dura be excised entirely, but I have found this unnecessary (Fig. 32).

The muscle edges are then brought together by interrupted sutures, the fascial edges united to each other, and the skin wound closed. It is seldom difficult or impossible to unite the edges of the temporal muscle, even if the protrusion be a very marked one. It is frequently difficult, however, to bring together the edges of the fascia, and it is often necessary to make relaxing incisions about 3 to 4 cm. from the fascial margins before the edges of the fascial incision can be brought together. A firm supporting dressing is then applied.

The operation of subtemporal decompression is never difficult, and the dangers from it very small. The first evidences of improvement, i. e. disappearance of the headache, cessation of vomiting and decrease of the papilledema, may be observed within 24 hours of the operation. The improvement may last for many months or years even without the occurrence of a large hernia. In rapidly growing tumors, however, a very large hernia may occur in spite of the submuscular operation.

Very great improvement may be expected in about 60 per cent. of the patients; slight improvement in about 20 per cent.; no change in about 20 per cent. It is rare for a patient in coma, the terminal stage of a brain tumor, to regain consciousness after the operation. Although Cushing speaks of the possibility of the appearance of localizing symptoms developing after the decompression where none existed before, it has been my experience that this is very rare. I have been able to save more than one-half of the patients upon whom I have done a large subtemporal decompression for bursting fracture of the vault and base who were operated upon when they were already in deep stupor.

Suboccipital decompressive craniotomy is indicated in all subtentorial lesions which cannot be radically removed, excepting primary growths of the pons or medulla. Suboccipital decompression has often been tried for midbrain lesions or in affections of the midbrain in which a cerebellar disease was suspected. It should never be done for tumors of this region; the symptoms are rarely improved, usually become aggravated.

The *technic* of suboccipital decompression consists of the bilateral removal of the bone in the suboccipital region, including part of the margin of the foramen magnum, and will be described in detail in the section devoted to the operative treatment of subtentorial disease. The opening in the skull should always be a bilateral one, and the dura should be widely opened by a transverse incision across the median line with secondary dural incisions radiating upward and downward from the primary one. The occipital sinus must usually be ligated, and care must be taken to avoid injury to the transverse sinuses in the upper part of the wound area. To avoid repetition the reader is referred to the section on subtentorial operations for new growths for further technical details.

Suboccipital decompression will do little good in supratentorial expanding lesions; it will relieve the headache, vomiting, and choked disc of cerebellar neoplasms. The true cerebellar symptoms, ataxia, nystagmus, etc., sometimes disappear entirely, but more often persist in a more or less diminished degree.

The operation is more time-consuming and complicated than subtemporal decompression, and therefore more dangerous, and some patients stand the interference poorly. While the subtemporal operation should have no mortality, the suboccipital will always have to show some fatalities due to the interference itself.

Transsphenoid removal of the floor of the sella turcica for the relief of the symptoms of tumor of the hypophysis is in many cases only a "sellar decompression," and is therefore referred to in this place. I shall speak of this and other methods for the relief of pressure upon the optic chiasm in the section devoted to the operations upon the hypophysis.

Other Procedures.—Recently Hudson, of Atlanta, Georgia, and McGuire, of Buffalo, New York, have described new procedures for cerebral decompression in which the osteoplastic flaps are made and the bone flaps not removed, but held in a new location by wire sutures. I have had no experience with any of these methods.

THE NON-OPERATIVE TREATMENT OF TUMORS OF THE BRAIN

New growths of the brain tissue or those impinging upon the brain or intracranial nerves may be grouped into the following classes: 1. *Those that are removable:* In this class are included tumors of the bone in accessible locations; tumors of the dura in accessible locations; tumors which arise from nerve trunks, such as neurofibroma of the auditory nerve, tumor of the Gasserian ganglion, etc.; tumors of the brain tissue itself which are not extensively infiltrating. 2. *Tumors that are not removable,* either on account of their location (midbrain, ganglia, most tumors of the ventricles, etc.), or on account of their nature (infiltrating growths in most locations, metastatic tumors, etc.), or on account of their intimate connection with vital parts (many tumors of the hypophysis, many growths of the vermis, etc.).

In spite of the most careful neurological examinations, however, it may be impossible to determine before an operation in which of the above groups a case must be placed, so that many of our operations are exploratory in nature.

The diagnosis of brain tumor having been made and syphilitic disease excluded, the non-operative treatment can, in the large majority of instances, aim only at an attempted relief of the patient's symptoms. If it has been definitely decided that an operation is contra-indicated, that not even a decompressive craniotomy will palliate the symptoms, then we can do little to make the unfortunate patient comfortable for the short time that is left to him. The violent headaches and the vomiting may be somewhat relieved by morphin, the failing vision may be temporarily improved by repeated lumbar punctures, severe convulsive seizures may be controlled by inhalations of chloroform, but these are palliative methods which add but little to the patient's comfort and death is usually welcome to these unfortunates. Blind and helpless, they may linger for many months until relieved by death.

Some tumors of the hypophysis, in which the patient's symptoms are due to a lack of the internal secretion of one part of the gland, can be benefited by feeding with gland extracts. On account of the correlation of many of the ductless glands, it may be that, in the future, other gland extracts will be found to be of benefit in hypophyseal conditions (dyspituitarism, hyper- or hypopituitarism), but our present knowledge of the ductless glands and their interrelation is still very limited (Nothnagel, Biedl, Eppinger, and Hess).

It may be that radium emanations will be found to exert a beneficial effect upon some forms of brain tumors, but we still lack definite information in this field.

I have failed to find any beneficial effects from the injections of the mixed toxins of erysipelas and Bacillus prodigiosus of Coley in malignant tumors of the brain or nerves.

THE OPERATIVE TREATMENT OF BRAIN TUMORS

The only method of treatment from which we may expect a complete and permanent cure is an operative interference, and the surgical treatment of tumors of the brain is one of the triumphs of scientific medicine of the end of the nineteenth century, based as it was upon the increase of our knowledge of cerebral localization and the great advances in surgical methods and operative technic.

Wernicke was the first to recommend very strongly the advisability of operative interference in tumors of the brain, while Bennett and Godlee were the first to correctly diagnosticate and remove an intracranial neoplasm. It was again Victor Horsley who led the way in this new field and successfully removed new growths from the brain, and he was soon followed by English, American, and Continental surgeons, among whom may be mentioned Macewen, Keen, Weir, McBurney, v. Bergmann, Krause, Borchardt, Cushing, Frazier, von Eiselsberg, and many others.

The field for the surgeon's activity was at first thought to be limited to the motor convolutions, but with increasing knowledge the field has been much widened. Almost every part of the brain is now accessible to the surgeon. The approach to the hypophysis and the accessibility of growths in the fourth ventricle are the latest triumphs of the pathfinders in this field, and we may hope that it will not be long before some as yet inaccessible parts of the brain, such as the pineal gland, will be attacked with safety by the surgeon.

Unfortunately, although the different parts of the brain have become accessible, it is only a small percentage of tumors whose nature allows of their successful removal. According to various statistics, both from the operating-room and from the post-mortem table, only from 3 to 8 per cent. of tumors which can be correctly localized are of such a nature as to allow of their successful removal. While the number is small, can there be any question as to the correctness of the viewpoint that the removal of a brain tumor should be attempted whenever possible? I do not think so; for the surgical treatment is, and promises to be for many years, the only method of cure. With improvement in diagnostic methods and improvement in technic great advances are certain to come. Progress will be made only by those who devote themselves to this special branch of surgery.

GENERAL PRINCIPLES OF IMPORTANCE IN THE OPERATIVE TREATMENT OF INTRACRANIAL NEOPLASMS

The Prevention of Hemorrhage.—Success in the removal of intracranial new growths will only come to those surgeons who realize the importance of limiting the loss of blood during the operation. Patients will usually bear operations upon the brain quite well if the bleeding has been kept in check. Bleeding from the scalp must be prevented by the use of the tourniquet or the hemostatic suture, bleeding from the bone by the free use of wax and gauze compression. It is always better to interrupt the operation until oozing has been controlled by pressure of gauze than to attempt to work while the oozing is going on.

Rapidity of Operation.—The more or less mechanical part of the operation, namely, the making of a bone flap, should be accomplished as quickly as is commensurate with safety, and can usually be completed in 15 or 20 minutes or less. We are not in sympathy with those operators who believe that an hour is not too long for this part of the procedure.

The Control of Intracranial Pressure.—If, upon exposure of the dura, the latter is found to be very tense, it is advisable to attempt to decrease this pressure before the dura is opened. The marked herniation of the brain which occurs when the dura is incised makes injury of the delicate brain tissue almost unavoidable. The methods for decreasing the tension are lumbar puncture, ventricular puncture, making a decompressive opening over a silent area, raising the head end of the operating table. Any or all of these procedures may be required. In the presence of marked internal hydrocephalus I have found puncture of the corpus callosum (q. v.) very useful.

Even when a tumor has been removed, the intracranial pressure may remain so high that accurate approximation of the dural edges is impossible without the addition of some of the procedures just mentioned. It should always be our endeavor to close the dura. If this cannot be accomplished the exposed brain should be covered with Cargile membrane, or a piece of fascia lata should be transplanted.

If the tension cannot be relieved it is better to remove the bone from the flap than to attempt to return it into place. Much injury to the cortex is apt to be caused by attempts to push back a bone flap under these conditions.

The utmost gentleness should be used in removing a growth from the brain tissue. It should not, as I have seen operators do, be roughly peeled out, but it must be separated from its attachments with great care and slowness. If the cortex has to be incised the pial vessels should first be tied with very fine silk. During the removal of the tumor bleeding must be controlled by ligatures of larger vessels, by pressure with small bits of absorbent cotton, or muscle tissue taken from the edges of the wound.

Tumors of the dura can usually be removed with little difficulty, although it may be necessary to excise a piece of dura with the tumor. Well-localized and encapsulated growths in or under the cortex must be shelled out with great care after the proper line of cleavage between tumor and brain tissue has been found. It is seldom advisable to attempt to excise an infiltrating growth unless it be very small, because its radical removal is never possible.

TUMORS OF THE CONVEXITY OF THE HEMISPHERES

The new growths which arise from the inner surface of the dura mater are, unless they are very large, quite easily removed. They are usually well encapsulated and easily separated from the cortex of the brain.

As soon as the dura has been exposed through an osteoplastic flap the neoplasm can be felt through the membrane. If the tumor is very large it may be necessary to remove it at a second operation; if it is small, no larger, let us say, than a small apple, it can usually be removed at once. The incision of the dura should be begun on one side of the tumor so that the operator can determine whether he will have to excise a piece of dura with the growth. Usually this will not be necessary, for it will be found that the growth is easily peeled off the inner surface of the membrane. The growth is then carefully freed from its attachments and lifted out of its bed in the cortex, small vessels being tied with fine silk and oozing controlled by small pledgets of cotton. Within a few minutes after the removal the brain will fill up the depression. After all oozing of blood has been controlled, the dura is closed by interrupted sutures, the bone flap returned into place and sutured in the usual manner.

If a portion of the dura has to be excised, as is often the case in tumors of the outer surface of the membrane or those which have perforated the dura, the defect should be closed by a flap of the outer layer of the dura or by a fascial flap taken from the fascia lata.

TUMORS OF THE FRONTAL LOBES

In making an osteoplastic flap over the frontal lobes the operator must be careful not to open into the frontal sinus. If a sufficiently large bone flap has been made, one will have no difficulty in examining all parts of the frontal lobe and in palpating the under surface of the lobe. It is perfectly safe to make an incision in the right or the left frontal lobe in order to expose a subcortical growth as long as the incision is made well forward so as not to injure long motor association tracts.

If an infiltrating tumor be found, every effort should be made to close the dura and return the bone flap into place, because a hernia cerebri in this location is a very great deformity. It is usually necessary to do both a subtemporal decompression and a ventricular puncture before the dural edges can be brought together by suture.

In the removal of a growth from the under surface of a frontal lobe the operator must guard against any injury to the olfactory bulb.

TUMORS OF THE TEMPORAL, PARIETAL AND OCCIPITAL REGIONS

Great care must be taken if the cortex over the Rolandic area has to be incised for fear of permanent paralysis of one or more extremities. Especial care must be taken if the operation is low down on the left side (on the right side in left-handed individuals) on account of the danger of making the patient aphasic. It is questionable whether an incision in the left temporal lobe is ever justified because the patient is very apt to lose his speech after such a procedure, while on the right side an incision can be made without danger of interference with the mechanism of speech.

In the exposure of tumors situated low down in the temporal lobe it is often advisable to remove a good deal of bone down to the base of the skull, as is done in the operation for exposure of the Gasserian ganglion. In this way a good exposure of the under surface of the temporal lobe can be obtained.

If an opening is made into a ventricle by the removal of a subcortical growth, it is not necessary to make any attempt to close the opening. I have found it useful to cover the part of the cortex concerned with a small piece of Cargile membrane, which will adhere to the surrounding cortex and will thus shut off the ventricular opening.

SUBTENTORIAL TUMORS

The removal of a tumor from the substance of a cerebellar hemisphere or from the cerebellopontine angle is a more difficult and trying operation than that in the cerebral lobes. These subtentorial operations must usually be done in two stages, as the patient's resisting powers are much taxed by the craniotomy.

When the dura has been incised the hemisphere is carefully palpated and, if necessary, punctured with an aspirating needle. If a tumor is felt beneath the cortex a transverse incision is made after ligation of large pial vessels. The bleeding from the substance of the cerebellum is usually small and easily controlled. If an infiltrating growth is found it is justifiable to excise a large part of the hemisphere, unless the growth is so large that it cannot be removed.

If a tumor is found on the upper surface of a hemisphere, considerable venous bleeding may occur during its removal, on account of small veins which run from the surface of the hemispheres to the transverse and superior petrosal sinuses. This bleeding can generally be controlled by gauze packings.

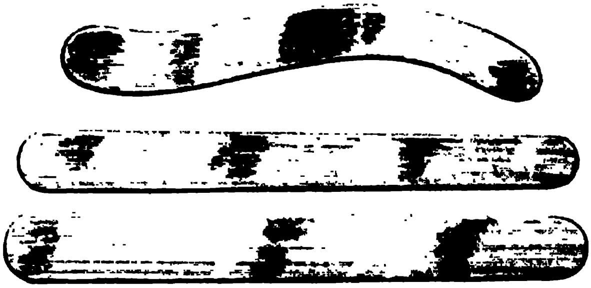

FIG. 33 FLEXIBLE BRAIN DEPRESSORS.

There is no operation which is a greater test of the ability of a neurological surgeon than the removal of a growth from the cerebellopontine angle. These tumors are usually of slow growth and but loosely attached to the brain or nerves. They most often originate from the auditory nerve and have the structure of a neurofibroma. If the tumor be a small one, not larger than a cherry, its removal can be accomplished successfully if the surgeon works with care and gentleness. If, as is often the case, the tumor is as large as a goose egg or still larger, its removal may be exceedingly difficult (Fig. 34).

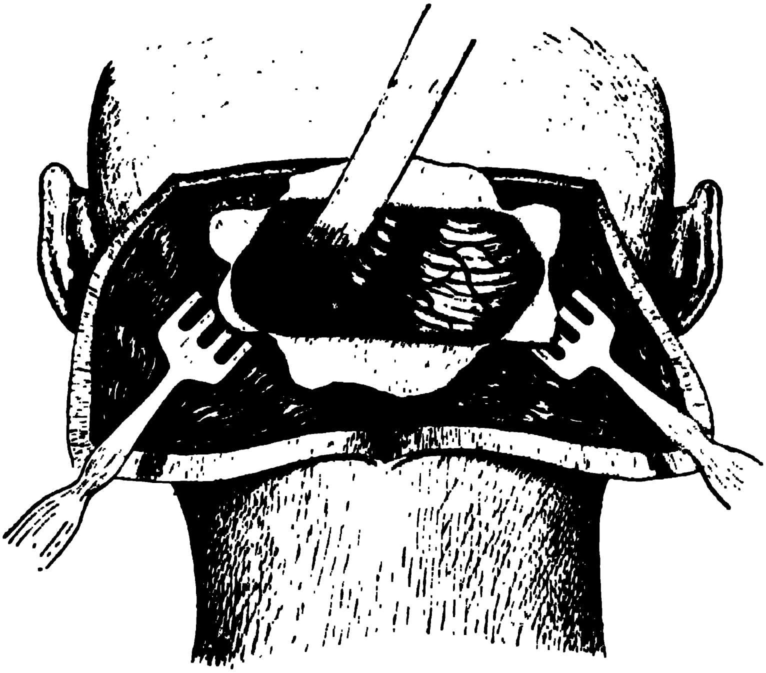

FIG. 34.—EXPOSURE OF TUMOR IN LEFT CEREBELLOPONTINE ANGLE.

The tumor is exposed by slowly drawing the cerebellar hemisphere toward the median line, thus dislocating the entire cerebellum toward the other side. A medium-sized brain depressor (Fig. 33) is bent to the proper angle and introduced along the outer side of the cerebellum. If the bone has been removed sufficiently far into the mastoid process, this can be accomplished without trouble. The cerebellum is then slowly drawn toward the other side, exposing the posterior surface of the petrous portion of the temporal bone. At this time there is usually a sudden gush of clear fluid from the depth, due to rupture of the lateral subarachnoid cistern. This fluid is carefully sponged away, and a larger retractor is more deeply placed over the other retractor which is then carefully removed. By this time, the growth will probably have been exposed, and its size determined. The operator then begins to separate it from its attachments on the mesial side. If there is considerable oozing of blood, the lateral recess must be gently packed with gauze for a few minutes. Working his way around the growth very carefully and gradually, and always making all movements away from the pons and medulla, the tumor is gradually freed from its attachments and removed. It may be found necessary to divide the auditory nerve before the tumor is free, but small growths can be peeled off the nerve without difficulty. Care must be taken not to injure the facial nerve which is often stretched over the anterior surface of the tumor.

When the tumor is a very large one, the least manipulation or handling of the growth may bring on respiratory disturbances so that the operator is in a quandary as to what he should do. If the cerebellum cannot be sufficiently dislocated, so that the operator can work without getting too near the brain stem, it may be advisable to defer the actual removal of the growth to a third sitting. In one of my operations I followed this plan, and was able to remove a very large growth from the cerebellopontine angle at a third sitting, with recovery of the patient.

Great care must be taken, during all of these manipulations, to protect the cerebellar tissue from injury; if the pia has once been torn, it is almost impossible to prevent laceration of the cerebellar cortex.

After the tumor has been removed, and all bleeding has been controlled, the brain retractor is carefully withdrawn, the hemisphere allowed to slip back into its fossa, and the wound of the soft parts closed in the usual manner. It is usually unnecessary to attempt to close the dura; this is unnecessary because the thick muscles in the suboccipital region form an adequate protection for the cerebellum.

Frazier has suggested that a part of the cerebellar hemisphere should be excised in order to well expose a tumor in the lateral recess, and he declares that such an incision will often cause no permanent symptoms. The excision of cerebellar tissue is seldom, if ever, necessary.

Some writers have advised that the lateral recess should be explored with the finger before it is exposed by dislocation of the cerebellum. I consider it dangerous to do any exploration in this region with the finger.

Bilateral Suboccipital Craniectomy with Removal of Part of Margin of the Foramen Magnum and of the Arch of the Atlas.

Most tumors of the vermis are infiltrating and cannot be removed.

Krause has several times opened into the fourth ventricle in operations in this region, and he states that the fourth ventricle can be opened without very great danger. I have once widely exposed the fourth ventricle in the attempt to remove a large growth of the vermis. The tumor could not be removed, but the patient recovered from the operation.

APPEARANCE OF THE NORMAL AND ABNORMAL CORTEX

The appearance of the cortex under normal and pathological conditions must here be described, for it is important for the surgeon to be able to recognize what is normal and to differentiate it from what is diseased.

Normally there should not be any adhesions between the dura and the pia arachnoid excepting in the location of the Pacchionian bodies. The surface of the brain should be of a creamy pink color and the vessels in the pia should be fairly well visible. Whitish thickenings in the walls of the larger pial veins are sometimes seen and usually have no pathological significance. When the pia mater, which normally is not to be seen as a membrane excepting where it bridges over a small fissure, is edematous or chronically thickened, a thickening of the walls of the veins is a further evidence that the process is not a very recent one.

It is often exceedingly difficult to recognize a gliomatous change in the cortex, for it may have all the appearances of a normal brain tissue. Sometimes by palpation one can feel a difference in consistency of the suspected part of the brain.

Infiltrating gliomata or gliosarcomata of the cortex present a very characteristic appearance. They are usually of a bluish color and are slightly elevated above the surface of the cortex.

When there is considerable bulging of the brain tissue, small, reddish-brown areas which look like tumor tissue often occur in the cortex. Such an error has often been made, but it should not occur if the surgeon remembers that the discoloration has occurred in a part of the cortex which had before appeared entirely normal. If such a small hemorrhagic spot is watched, it will often be seen to grow larger and slightly prominent. If a small hemorrhagic area is incised, the brain tissue will be found to be discolored and soft so that it would be easy to mistake it for a tumor. Such an error is never made by the operator of experience.

PIAL ANGIOMATA OVER THE HEMISPHERES

In the majority of instances, it is impossible to make the diagnosis of the condition before the exposure of the brain, the angioma being recognized only on the operating table. Sometimes enlarged veins can be seen through the thinned and translucent dura, but more often, the presence of the varicose tumor is suspected on account of the lively bleeding that occurs as soon as the first incision in the dura has been made, or the tumor is seen as soon as the dural flap has been reflected. The operator must be especially careful to expose the entire mass of blood vessels freely before he attempts to ligate and excise them, and all manipulations must be done with extreme care so as to avoid injury to any of the smaller vessels.

After the mass of vessels has been exposed, a large tributary is selected, 2 ligatures of fine silk applied, and the vessel then cut between the ligatures. The vessel walls are usually easily torn, and the bleeding which ensues may be difficult to control. If the operator attempts to catch the bleeding vessel with artery forceps, he is almost certain to injure other vessels, a large hematoma quickly forms, and thereafter the difficulty of identifying any landmarks is very great. The surgeon must work his way gradually around the tumor, and be on the lookout for the tributary vessels which enter the mass from the brain itself.

CYSTS AND CYSTIC COLLECTIONS OF FLUID IN THE BRAIN

The exposure of cysts or cystic fluid collections in different parts of the brain is accomplished in the same manner as that of new growths, for the differential diagnosis between tumor and cyst is usually made on the operating table.

Cystic collections of fluid outside of the brain, the so-called meningitis serosa circumscripta of Oppenheim and Krause, are rare and are only found in the posterior cranial fossa. Undoubtedly in some instances, a distended posterior or lateral cistern has been mistaken for a cystic collection of fluid, the sudden escape of a large quantity of fluid from the side of a cerebellar lobe with immediate relief of increased intracranial pressure, leading the operator to believe that he has opened a collection of fluid which has been the cause of the patient's symptoms.

When fluid is obtained by aspiration of the brain tissue, the operator has to make certain that he has not aspirated a distended lateral ventricle. In the large majority of cases, cyst fluid is of a more or less yellow or greenish color while normal cerebrospinal fluid is perfectly clear. The surgeon must remember, however, that an old hemorrhage into the ventricles or a rapidly growing tumor near a lateral ventricle may cause a yellow or greenish discoloration of the ventricular fluid.

True cysts of the brain are either the results of an old hemorrhage, or of the softening of the central portions of a soft glioma; they are either parasitic or of unknown origin.

When the surgeon has determined by aspiration that he has to deal with a cyst, it is necessary for him to incise the brain tissues and lay the cyst cavity wide open. When this has been done, the lining membrane of the cavity should be examined and if the cyst wall is a thick one, it must be excised. Generally, this is impossible and all that can be done is to swab out the interior of the cyst with tincture of iodin.

If it is found that the cyst cavity connects with one of the ventricles, the same treatment can be applied to it as to an ordinary cyst.

If the walls of the cyst show a tendency to fall together, it is a good plan to insert a small strip of Cargile membrane into the cavity and lead it under the dura, so as to insure the proper drainage of the fluid into the subdural space.

The surgeon must be guarded as to his prognosis in cysts of the brain unless he is certain that he has to deal with a simple cyst. It is often impossible to differentiate the latter from gliomatous cysts. The patients often recover entirely from their symptoms and remain well for a number of years. Then the symptoms recur and at the second operation an infiltrating and irremovable glioma is found. The prognosis of simple cysts is, of course, excellent, and some of the most satisfactory results of brain surgery are obtained when thick-walled cysts have been removed.

TUMORS OF THE GASSERIAN GANGLION

The removal of tumors of the Gasserian ganglion, of which a few have been reported, is usually not difficult, and is accomplished by an operative procedure identical with that for the exposure of the Gasserian ganglion in operations for major neuralgia of the trigeminal nerve. The tumors are usually derived from the dural sheath of the ganglion and are typical dural endotheliomata. For the method of their removal the reader is referred to the chapter on Gasserian Ganglion Operations.

RESULTS OF OPERATIVE TREATMENT

The removal of tumors in the posterior fossa has been attended with a much greater mortality than the extirpation of growths from the cerebral hemispheres. The mortality has differed also in the hands of different operators. According to Oppenheim and Bruns about one-third of the patients die as a result of the operation, and in only 9 per cent. are the growths of such a character and in such a location that they can be removed. In a number of these, symptoms which result from the extirpation are of such a nature that it is unfair to speak of a satisfactory result from the operation. Oppenheim concludes that in only 3 to 4 per cent. of the patients can a definite cure be expected.

I might quote statistics collected from a number of sources, and these might appear to bear out the very pessimistic view of Oppenheim. It is better, however, to examine the results of those who have had a large experience in brain surgery in order to gain an adequate idea of what can be accomplished. If this is done, several features at once stand out clearly. First, the results of operations are steadily improving, due to the fact that physicians are beginning to realize that operations upon the brain should only be performed by those specially trained in this field. Neurological surgery is truly a specialty of surgery. The neurological surgeon must be a well-trained organic neurologist, he must be able to think neurologically, and must have a thorough knowledge of the gross and minute anatomy of the central nervous system. He must be able to visualize for himself the condition of affairs in each case, so that he can attack each case in the proper manner; he must be able to stand on his own feet and not have to be instructed by the neurologist where to attack and how to approach the neoplasm. In the hands of the general surgeon, there has been little progress, but in the hands of the special worker, such as Horsley, Cushing, Krause, and others, the results have steadily improved.

In the second place, we are beginning to realize that in the large majority of instances, the attempt to radically remove infiltrating growths of the brain is hopeless, and a timely word was spoken by Tooth when he advised that **infiltrating growths should never be removed,** that in these patients a palliative operation should be performed. In the large majority of cases, as much will be accomplished by a palliative operation, relief of the symptoms for six months to two years, as by an attempt at complete extirpation of the growth.

The best results can be obtained in the so-called endotheliomata of the dura and the tumors which grow from some of the cranial nerves, tumors of the auditory nerve, of the Gasserian ganglion, etc. The prognosis of operations for cysts of the brain is good, provided that the surgeon is dealing with a simple cyst and not with cystic degeneration of the central part of an infiltrating glioma. In the latter case, the symptoms are certain to recur within a few years or less. Borchardt has recently reported 13 lasting cures among 14 operations for cysts of the cerebellum; the figures of Tooth, from the Hospital for Paralyzed and Epileptic (Horsley, Armour, Sargent, Ballance), are about as good.

It is quite a different matter when we have to deal with a tumor within the brain tissue. If the tumor is an encapsulated one, we may expect a good result when it is of small size and can be reached without injury to important nerve tracts. The larger the growth and the deeper its location, the worse the outlook. It is more than useless, as Horsley has done, to remove a deeply seated tumor and leave the patient permanently paralyzed through the injury that had to be inflicted in order to reach the tumor. Incision and exploration of the right temporal lobe are justifiable because they can be done without causing many symptoms, but exploration of the left side will often leave behind symptoms worse than those caused by the disease.

In a consideration of the result that we may expect from an operation for brain tumor, we must remember that there is the possibility of error in localization. With increasing knowledge of cerebral localization, however, such errors are certain to become less and less frequent. Then also, the nature of the lesion may be different from that expected; we may have to deal with an area of softening, with an abscess, or the symptoms are those of a "pseudotumor." I should arrange the operability of brain tumors in the following order,—tumors of the dura and nerves, of the central convolutions (because they give localizing signs early), of the parietal region, of the left frontal lobe, of the occipital lobe, of the temporal lobes, of the cerebellar hemispheres, of the cerebellopontine angle, of the hypophysis.

In the large majority of instances tumors of the brain stem, the medulla and pons are easily diagnosticated and therefore not apt to be operated upon. New growths of the corpus callosum and central ganglia are not easily diagnosticated and are occasionally operated upon.

The exposure of the cerebellum is a more serious procedure than the exposure of the cerebral hemispheres, and the mortality from the operations in the posterior fossa has been much larger than from interference in other parts of the brain. Thus of 44 cases collected by Leischner, 29 died soon after the operation (70 per cent. mortality), 2 were cured, 9 improved, 2 died later. V. Eiselsberg had 10 cases with 6 deaths; Henschen collected 42 cases with 8 recoveries; Horsley reported 10 operations with 2 deaths.

Of 101 cases collected by Borchardt in 1907, 55 died soon after the operation. In 55 patients the tumor was not found, and of these 33 died. The tumor was found in 46 patients; 27 were entirely relieved of their symptoms or were improved. According to Hildebrand, of 30 patients operated upon for tumor of the cerebellopontine angle, only 7 recovered from the operation, while Krause saved 6 of 9 patients, and Borchardt himself 1 out of 7. Diller and Gaub published some of Cushing's results: 30 cases with 2 deaths; 11 times the tumor was found and removed at the first operation; 12 times a decompressive operation was done; twice the tumor was removed at a second operation. Cushing believes that the results of cerebellar surgery should be fully as good as those of operative interference in new growths of the cerebral lobes.

In Krause's work, "Chirurgie des Gehirns und Rueckenmarks," the following cases are cited: 8 operations over the central convolutions, 2 angiomata over the cortex, excision and recovery; 1 endothelioma, recovery; 1 tuberculoma, death after one month; 1 diffuse glioma of cortex, death; three subcortical tumors, 1 cysticercus, death; 1 glioma, death; 1 fibrosarcoma, recovery without improvement.

Temporal lobe: 1 fibrosarcoma of cortex, recovery, two recurrences, death after three years. Parietal lobe: 1 fibrosarcoma of cortex, death. Occipital lobe: 1 sarcoma of dura, recovery; 1 fibrosarcoma of cortex, recovery; 1 sarcoma of dura, death; 1 sarcoma of lobe deeply situated, death.

Posterior fossa: 3 cysts of cerebellum, 3 recoveries; 1 sarcomatous cyst, death; 1 fibrosarcoma, 1 fibroma of cerebellopontine angle, recovered; 1 fibroma, 1 sarcoma of angle, died; 1 tumor of worm, 1 endothelioma of worm recovered, 1 cystic sarcoma of worm died; 1 tumor of base pressing upon cerebellum and pons, died.

Tooth's statistics from the Hospital for Paralyzed and Epileptic in London, published in the proceedings of the Seventeenth International Medical Congress, 1913, are as follows:

GROSS MORTALITY

	Removal, Complete or Partial			Exploration			Decompression		
	Number	Fatal	Per cent.	Number	Fatal	Per cent.	Number	Fatal	Per cent.
Frontal..........	31	18	58.	17	12	70.5	22	15	68.1
Central..........	30	21	70.	14	10	71.4	10	8	80.
Temporal........	7	3	42.8	14	8	57.1	9	5	55.8
Occipital........	2	2	100.	3	2	100.	2	2	100.
Cerebellar.......	11	7	63.6	14	8	57.1	8	4	50.
Extracerebellar ..	24	17	70.8	1	1	100.	11	10	90.9

CASES WHICH PROVED FATAL WITHIN ONE YEAR OF OPERATION

	Removal, Complete or Partial			Exploration			Decompression		
	Number	Fatal	Per cent.	Number	Fatal	Per cent.	Number	Fatal	Per cent.
Frontal..........	31	14	45.1	17	10	58.8	22	10	45.4
Central..........	30	15	50.	14	8	57.1	10	8	80.
Temporo-sphenoidal.....	7	2	28.5	14	7	50.	9	5	55.5
Cerebellar.......	11	7	63.6	14	6	42.8	8	4	50.
Extracerebellar ..	24	17	70.8	1	1	100.	11	9	81.8

TUMORS OF THE HYPOPHYSIS

In spite of a large number of researches on disorders of the pituitary body, in the front rank of which must be placed the remarkable investigations and experiences of Harvey Cushing and his co-workers, our knowledge of this as well as of all the other "ductless" glands or bodies is still a very meager one. In a consideration of this subject, we are confronted by a number of problems, "some of which call for mere symptomatic medicinal measures, some for operative relief, and some for the administration of glandular extracts to make up for a deficient secretion." (Cushing) "One patient may need merely a sellar decompression to alleviate the headaches of capsular distention, another may require partial extirpation of a struma to relieve chiasmal pressure, another, who has no neighborhood symptoms, may require merely glandular feeding."

"On the other hand, combinations of these methods may be needed. Thus one and the same individual may urgently require subtemporal decompression for the relief of general pressure symptoms, and subsequently the sellar floor, or even a portion of the large struma, may be removed by a transsphenoidal route to save the chiasm from further damage; at the same time the X-rays may be employed to check further cell division of an active chromophobe struma, the patient meanwhile receiving glandular administration to supply the secretory deficit. Hence the treatment of these cases is neither strictly surgical nor medical, but various methods must be adopted according to the immediate demands of the individual problem."

The above quotation from Cushing gives an excellent summary of the subject. In the following, I shall consider only the surgical procedures which may be required, and refer the reader to Cushing's monograph and to other publications, especially that of Biedl, on Internal Secretions, for a discussion of the medical and glandular treatment of hypophyseal disorders.

INDICATIONS FOR SURGICAL INTERFERENCE IN HYPOPHYSEAL DISEASE

The surgery of hypophyseal disease is still in the developmental stage, and our present opinions will no doubt be modified, if not entirely changed within a few years. Surgical interference may become necessary in these conditions for the relief of headache and other pressure symptoms, for the relief of local pressure symptoms, or to modify or diminish the symptoms of hyperpituitarism, especially when they are accompanied by neighborhood disturbances. In many conditions, operative treatment is unjustifiable. Thus when the symptoms are very slight and not progressive or only very slowly progressive, or when there is acromegaly without other symptoms or adiposity and sexual impotence, there is no justification for an operation. The same is true when there are only slight eye disturbances which remain stationary, nor is absolute blindness with slight symptoms, such as headache, an indication. I believe that up to the present time, the most urgent indication for an operation is growing diminution in the fields of vision with impending blindness, perhaps already blindness in one eye. If with this are associated severe headache and perhaps other neighborhood symptoms, then the justification for operative treatment is undoubted. The combination of acromegaly with these symptoms, when the latter are in an early stage but steadily progressive, will often form a sufficient reason for an operation.

The choice of operation will depend very much upon the experience and skill of the operator, and I shall do no more than describe the various methods of approach to the hypophysis, leaving it to the surgeon to select for himself the procedure he desires to adopt.

When there are marked neighborhood symptoms, due to the extension of the growth into the cranial cavity, an ordinary subtemporal decompression may be necessary, but I believe that this should always be combined with a puncture of the corpus callosum so as to relieve the hydrocephalus of the third ventricle which is so often present.

METHODS OF APPROACH TO THE HYPOPHYSIS

As is always the case when a method of treatment is in its developmental stage, a large number of methods for exposing the sella turcica and its contents have been described, many of them having been already tried in man, others having been worked out on the cadaver. It would occupy too much space even to mention all of them, nor would it be of real value to do so. The methods of access have been either transsphenoidal or intracranial.

According to Cushing, an approach to the hypophysis with osteoplastic resection of the anterior wall of the frontal sinus and nose was proposed by Giordano in 1897. Schloffer improved the procedure of Giordano, and he was followed by Hochenegg, v. Eiselsberg, Kocher and others, each surgeon modifying and improving upon the procedure described by his predecessor. Thus in the place of resection of the frontal sinus as practiced by Schloffer and v. Eiselsberg, Kocher simply deflected the nose to one side and crushed the turbinate bones to each side. But all of these operations were very mutilating, extensive incisions were made on the face and forehead, and deforming scars remained.

Kanavel first showed that it was possible to reach the sella through the inferior nares, the nose being turned up after an incision at the nasolabial junction, and the turbinates and part of the septum being removed. Kanavel, Mixter and others were able to successfully reach the sella turcica in this way. Halsted then suggested a sublabial incision instead of the infranasal incision and operated successfully by the sublabial inferior nasal route. The method adopted by Cushing is a transsphenoidal approach through Halsted's incision, although modified in many details by Cushing. Finally, it must be mentioned that Hirsch, of Vienna, has successfully operated upon a considerable number of patients by the endonasal route, the entire operation being performed under local anesthesia through one nostril after resection of the septum. I believe that a sellar decompression is an operation which should be done by a skilled rhinologist who should have no difficulty in opening the sphenoidal sinuses under local anesthesia and removing the floor of the sella turcica. If, as Hirsch has done, the entire procedure can be accomplished with local anesthesia, what justification is there for prolonged operations under a general anesthetic by the surgeon? This statement has reference only to the operation of sellar decompression in which the floor of the sella turcica is removed and the dura opened, and perhaps a small amount of tumor tissue curetted out. As I shall state later, I favor rather an intracranial method of approach for reasons that shall be mentioned.

THE SURGICAL PROCEDURES

The anesthesia is of great importance in these operations and deserves a few special words. There is no doubt in my mind that the ideal anesthesia for this operation is the method of intratracheal insufflation. It is especially valuable when the transsphenoid operation is to be done, for the anesthetist is never in the way of the operator, the intratracheal tube lies in the corner of the mouth and is never in the way, and there is no possibility of blood or mucus running down into the trachea and lungs.

The danger of meningitis is considerable when the transsphenoid operation is done, and the patients should receive, for several days before the operation, full doses of urotropin. The danger of meningeal infection from the transfrontal operation is practically nil, that is it is no greater than after any intracranial procedure in which the dura is opened.

The advantages of the transfrontal approach over the transsphenoid are, I believe, the following: It is a surgically clean operation; the sella turcica and hypophysis can be clearly exposed and as much as necessary of the diseased parts removed under the eye, for the hypophysis, especially if it is enlarged, can be about as well seen as is the Gasserian ganglion in the low temporal method of approach to it in operations for trigeminal neuralgia. The scar that is left after the transfrontal procedure, as I have modified Frazier's operation, is very slight, and hardly noticeable after a few months. The operation is easy in the hands of any surgeon who is used to cranial work. Cushing, who is exceedingly skillful in the performance of the transsphenoid operation, declares the operation favored by him to be the operation of choice, and believes that the tumor is often sufficiently large to prohibit the degree of cerebral dislocation necessary to bring the interpeduncular space into view. In making this statement, I do not, however, believe that Cushing had the transfrontal method of approach in mind.

I believe that, if one could surely distinguish the cases in which a cyst was to be drained, the transsphenoidal sellar decompression would be indicated, while, if the diagnosis of a solid tumor was made, which can often be made by the X-ray, the transfrontal procedure would be advisable.

The Transsphenoidal Operation of Cushing (Fig. 35). The shoulders of the patient are slightly raised so that the head drops back into a moderate Rose position and the posterior nares occluded by a sponge. A cotton pledget is inserted into each nostril, the upper lip drawn up, and a transverse incision made across the frenum of the lip. The incision is carried down to the nasal spine and then the soft parts are scraped back on each side from the lower bony margin of the bony nasal septum opening until the cartilaginous septum is exposed.

The following description is quoted from Cushing's book, "The Pituitary Body and Its Disorders":

> "From this point on, the performance should be an entirely submucous one, the membrane being separated from the bony and cartilaginous septum on each side. In favorable cases . . . the entire operation may be conducted without entering the nasal cavity; however, owing to the firm perichondrial attachment at the anterior margin, a slight tear through the mucous membrane may occur on one side or the other at this point.
>
> "A deep smooth retractor 1.8 centimeters in breadth and 6 centimeters in length is then introduced on each side between the freed mucous membrane and the median

cartilaginous and bony septum. The separation of this pair of retractors will give sufficient room for the easy removal of the necessary strip of septum in a few large pieces. This will include most of the vomer, the lower edge of the median plate of the ethmoid, and a small strip of cartilage, in removing which Ballenger's swivel knife may be conveniently used. . . . With the original retractors still in place, a series of dilating plugs, running up to a diameter of 1.8 centimeters, are then introduced, separating the retractors to each side. . . . The two retractors are then withdrawn, their place being taken by a bivalve speculum, the blades of which are about 7 centimeters in length and 1.8 centimeters in breadth.

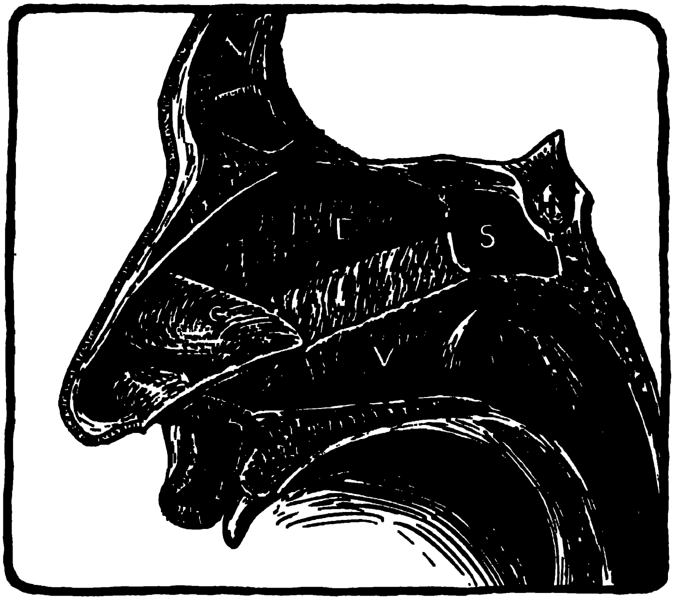

FIG. 35.—ANATOMY OF TRANSSPHENOID APPROACH TO HYPOPHYSIS. (Kanavel.)

"From this point the use of a headlight is essential. . . . The sphenoidal attachment of the septum is then identified and the 'prowl' of the vomer underlying the sphenoidal cells may be removed. With experience, the sphenoidal sinuses are easily identified, but it is well, in all cases, to keep the angle of approach low and to follow the posterior margin of the vomer, so as to minimize the chance of entering the posterior ethmoidal region through mistake.

"When the body of the sphenoid has been identified, the anterior and lower walls of the sinuses are chipped away with long-handled nasal rongeurs, and after the cells have been freely opened, and the lining mucous membrane removed; there is rarely any difficulty in recognizing the sellar protrusion, even where there is no pathological enlargement of the fossa. . . .

"The floor of the pituitary fossa is then removed in turn, this usually amounting, in the case of a tumor, to nothing more than the chipping away of thin bony scales, which are often the only remnant of the ballooned fossa. With a knife hook, which can be inserted through the capsule and drawn outward, a crossed incision is made in the dural encasement of the gland or tumor, and such a degree of extirpation as may seem advisable is then carried out.

"The transsphenoidal performance may resolve itself into any one of the following procedures: An infrasellar tumor arising from a hypophyseal rest may be encountered and removed; a mere sellar decompression with splitting of the glandular capsule may be performed; intrapituitary cysts may be found and evacuated; a fragmentary extirpation of a glandular struma or tumor may be combined with the sellar decompression."

The above quotation from Cushing gives an outline of the transsphenoidal operation. The entire subject is still so new that many modifications will surely be made, and we therefore refer the reader to Cushing's thorough and elaborate description of the procedure, its dangers and difficulties, and to the excellent paper by Lewis and Kanavel on the same subject.

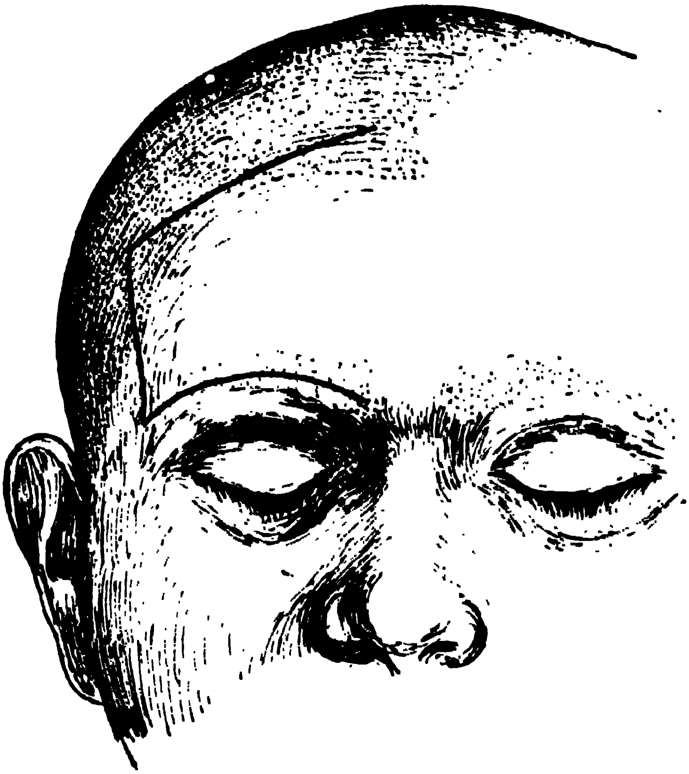

Fig. 36.—Author's Incision for Transfrontal Craniotomy for Exposure of Hypophysis.

The Transfrontal Approach by the Method of Frazier as Modified by the Writer.—Krause was the first to suggest an approach to the hypophysis through the anterior cranial fossa, while Borchard first attempted the operation in the human being. Methods for approach through the frontal bone were then worked out by Kiliani (1904), McArthur (1908), Bogoiavlensky (1912), but without doubt the best operation is that devised by Frazier (1913). The operation consists in the reflexion of an osteoplastic flap of frontal bone with its base in the temporal region, the removal of part of the supra-orbital ridge and portion of the roof of the orbit en bloc (later to be replaced), removal of the roof of the orbit down to the optic foramen, elevation of the frontal lobe and depression of the orbital contents, incision of the dura and exposure of the cavity of the sella turcica.

I have modified the operation in that the supra-orbital ridge remains attached to the bone flap and in making the base of the flap in the frontal region so as to avoid a scar on the forehead. The operation, as I perform it, is the following:

X-rays having been taken to determine the size and extent of the frontal sinuses, the side of the frontal bone is selected in which the sinus is the smallest. If the patient has lost the sight of one eye, it is best to do the operation on that side.

An incision is made from the inner angle of the eyebrow outward to the external angular process of the frontal bone, then upward and backward to within the hair line and then inward to near the median line (Fig. 36). With an ordinary trephine, openings are made at the beginning of the incision, just above the external angular process and at the upper outer and upper inner angles of the incision in the soft parts. The bone is cut in the usual manner with Hudson forceps. The soft parts are slightly dissected down from the supra-orbital ridge, the roof of the orbit about 1 cm. behind the supra-orbital ridge divided by slight blows with a small chisel, the supra-orbital ridge cut at each trephine opening with a Gigli saw or sharp Liston forceps, and the bone fractured toward the median line. On account of the thickness of the bone in the median line, it is usually necessary to partly divide the base of the bone flap with the cranial forceps.

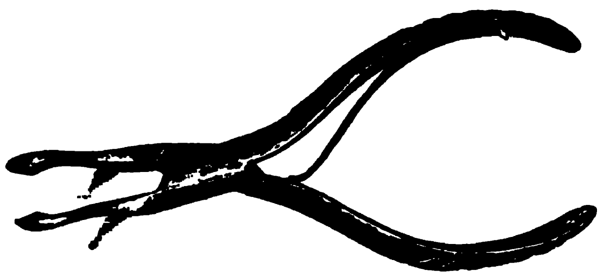

FIG. 37.—LONG-BLADED CRANIAL RONGEUR.

With various rongeurs, the thin roof of the orbit is removed down to the optic foramen, care being taken that the direction of the rongeuring is correct so as not to open into the ethmoid sinuses, and that the periosteum of the orbit is not injured. As the operator approaches the optic foramen, a long-bladed rongeur (Fig. 37) must be used, the orbital contents depressed and the frontal lobe in its dura slightly elevated. As soon as the optic foramen is reached, and after all oozing of blood has been controlled by gauze pressure, an incision about 3 cm. long is made from the exposed anterior clinoid process toward the median line, a small brain retractor introduced into the opening and the frontal lobe elevated. The optic chiasm, hypophysis and sella turcica are now in good view (Figs. 38 and 39).

When the treatment of the hypophyseal lesion has been finished, the bone flap is returned into place and the soft parts sutured in the usual manner.

The operation is not at all difficult in the hands of the surgeon experienced in cranial surgery, and an excellent exposure of the region of the hypophysis is obtained. It is possible to extirpate or partially remove a growth from around the pituitary body in full view, and the operation is surgically very satisfactory. The amount of elevation of the frontal bone that is necessary is not very great, so that no injury to the brain should occur. The orbital roof should be removed over an area about 2 cm. in width, and if an ethmoid sinus be opened it should be closed with a little Horsley wax. The supra-orbital ridge forms part of the osteoplastic flap which is better than if the bone is removed in one piece and later replaced as in Frazier's operation. The amount of visible scar is very small, only a small line between the external angular process of the frontal bone and the hair line.

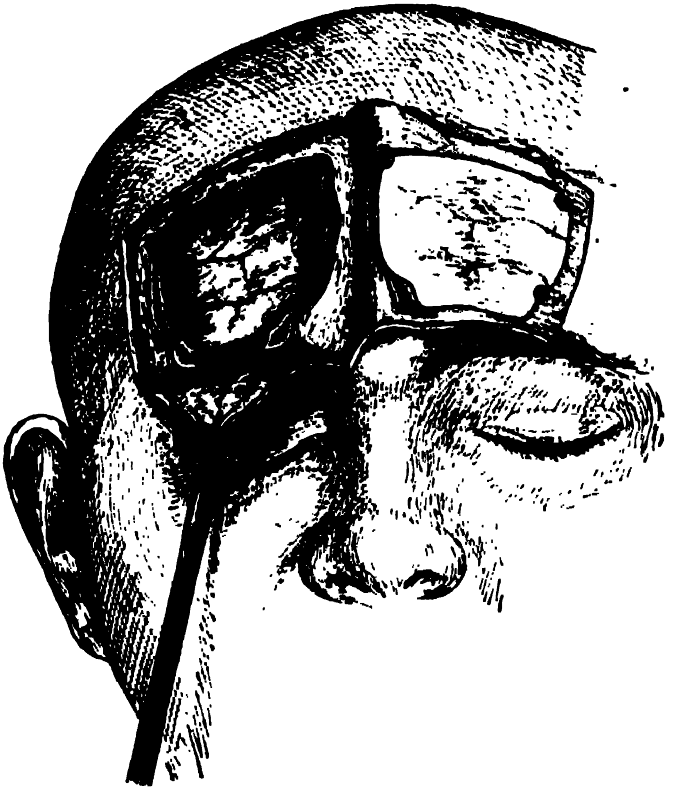

Fig. 38.—Transfrontal Craniotomy for Exposure of Hypophysis. Bone flap turned back.

TREATMENT OF ABSCESS OF THE BRAIN

In the following remarks, I shall confine myself to a consideration of abscess of the brain itself, and shall leave out of consideration the extradural abscesses which occur after ear disease or disease of the accessory nasal sinuses, because an extradural abscess presents none of the surgical problems that are to be solved before the surgeon can satisfactorily treat a collection of pus within the brain substance.

Brain abscesses are sometimes met with in exploratory cranial operations where the surgeon expected to find a neoplasm; more often the diagnosis of brain abscess is made before the operation, especially if the symptoms of intracranial disease have followed an old or recent middle-ear disease.

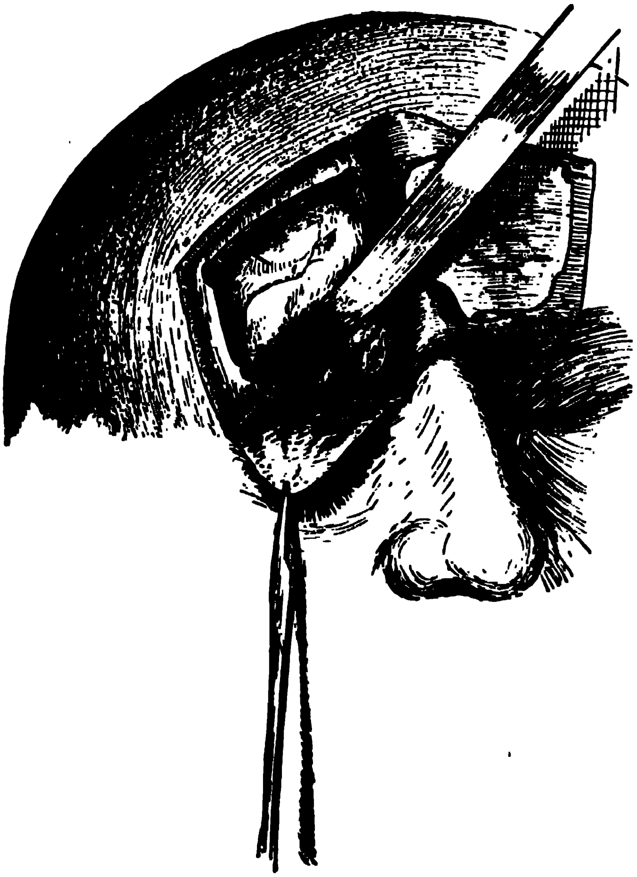

FIG. 39.—TRANSFRONTAL CRANIOTOMY FOR EXPOSURE OF HYPOPHYSIS. The hypophyseal growth is exposed.

When the surgeon suspects and operates for a brain abscess, it is inadvisable to make a bone flap if this can possibly be avoided. A trephine opening should first be made of a sufficient size to allow of thorough aspiration of the brain over the suspected area. A button of bone is removed with the trephine after a small incision in the scalp has been made. A nick is then made in the dura with a small scalpel and the brain aspirated in various directions, care being taken not to injure any pial veins with the aspirating needle. For this purpose

I generally use a needle with a blunt point such as has been described for lumbar puncture and aspiration of the ventricles.

If no pus is discovered by aspiration, it may be necessary to proceed to the making of a bone flap for thorough exploration. The small incision in the dura is closed with a silk stitch and the scalp incision sutured before the bone flap is made.

If pus is obtained by aspiration, the needle is left in place and the incision in the dura enlarged; the dura and pia-arachnoid are now swabbed with tincture of iodin. A grooved director is then pushed into the abscess cavity along the needle, and the latter is then withdrawn. The opening is enlarged with a small dressing forceps and a drainage tube inserted and fixed to the dura by one stitch of fine silk. If necessary, a few small gauze strips are packed all around the tube which is led out through the incision in the soft parts.

When an abscess is found after an osteoplastic flap has been made, the tube can usually be led out through a small trephine opening in the bone made in the center of the bone flap. The flap of bone and soft parts is then returned into place and sutured in the usual manner.

What has been stated above applies to abscesses deeply situated in the cerebral hemispheres. If the abscess lies near the surface of the brain so that it can be opened widely without too great injury of nerve tracts, the trephine opening should be sufficiently enlarged so that the entire affected region of the brain is exposed. The dura must then be freely opened and the abscess laid wide open by a free incision in the brain tissue, in order to obtain perfect drainage of the abscess cavity. In the cerebellar hemispheres, it is justifiable to excise a small piece of a lobe so that drainage conditions shall be as perfect as possible.

After-treatment.—The after-treatment of a brain abscess is of very great importance, for in not a few instances the drainage is not good, secondary abscesses develop causing increased destruction of brain tissue and perhaps rupture of an abscess into a ventricle with a fatal outcome. A large-sized drainage tube should always be used; I believe that some of the failures have been due to the use of too small a drain. The tube should not be removed for at least several weeks and if gauze drains have been used in addition, these should be allowed to remain in place for at least seven to ten days. Each time the wound is dressed, the skin, drainage tube and gauze should be painted with tincture of iodin, as this is the greatest safeguard we possess against secondary infection of the meninges from the outside. The drainage tube should always be fixed by a safety pin so that the end of the tube is not pressed into the brain tissue by the dressings.

Large doses of urotropin up to 100 grains a day should be given from the time of the operation, and should be continued for several weeks, unless hematuria develops.

Prognosis.—When an abscess has ruptured into a ventricle, the condition is usually a hopeless one, although one may prolong the patient's life by drainage of the affected ventricle. I am not aware that any case has recovered in which a brain abscess had ruptured into one of the ventricles.

The prognosis of brain abscess is always a serious one. The most favorable site is the one or other temporal lobe, and abscesses in this location secondary to ear disease offer a much better prognosis than those in other parts of the hemispheres. The mortality of deeply seated abscesses of the cerebral hemispheres is much greater than that of cerebellar abscesses.

The results of operations for chronic abscesses with sterile contents are much better than those for recent collection of pus containing the ordinary organisms of suppuration.

TREATMENT OF INTRACRANIAL HEMORRHAGE

When, after an injury to the head, signs of compression of the brain occur, the surgeon must determine whether the symptoms are due to a large collection of blood in the brain tissue, on the surface, or on the outside of the dura. When there is no fracture of the skull, opinions differ as to the proper indications for treatment, some surgeons believe that every patient with suspicious symptoms should be operated upon, others reserve for operation only those with very marked signs of cerebral compression. When there are marked slowing of the pulse and respiration, stupor, hemiplegia, and perhaps convulsions, the operative indications are clear. When the symptoms are less marked, careful observations as to their progressive character, especially slowing of the pulse and respiration, rising of the blood pressure, and enlargement of the veins of the retinæ, are necessary.

If the surgeon is in doubt, an exploratory skull puncture should be performed. By means of this little operation, which can be done under local anesthesia, we can determine not only whether there is a large collection of blood within the skull, but also whether it is located on the outside or inside of the dura.

The general and local pressure symptoms will indicate the side that has to be explored and if blood is obtained by aspiration, a craniotomy is indicated. Operations for intracranial hemorrhage give very satisfactory results, as the statistics given below will show, and the dangers of the operation are very small if the condition of the patient is not poor before the operation.

If an extradural or subdural bleeding has been diagnosticated, the skull should be opened by removal of the bone; osteoplastic craniotomy should be performed only for hemorrhage within the brain substance. If the operation fails to reveal any large collection of blood, a subtemporal decompression should be performed so as to relieve the increased intracranial tension which may be due to multiple small bleedings throughout the brain tissues.

If bleeding from a middle meningeal artery is suspected, an opening should be made in the middle of the temporal region. This opening should be fairly low down so that the main branch of the artery can be exposed. Krönlein has shown that after injury of the anterior branch of the artery, a hematoma is apt to form in the frontotemporal region; after injury of the posterior branch, in the parieto-occipital region; after injury to the main artery, low down in the temporoparietal region (Fig. 40), and he designated two regions where the trephine openings should be made. I believe that it is always better to remove a button in the mid-temporal region, and then to rongeur away the bone anteriorly or posteriorly as required. As soon as the dura is exposed, the blood clot must be washed away with a stream of warm solution and by means of gauze sponges; the operator must make a thorough search for the bleeding point and must apply a ligature to it; he should not be satisfied if he has removed the blood clot without finding the source of the bleeding. If no bleeding point can be discovered, it is advisable to drain the wound with a small piece of gauze, lest bleeding should recur after the wound has been closed.

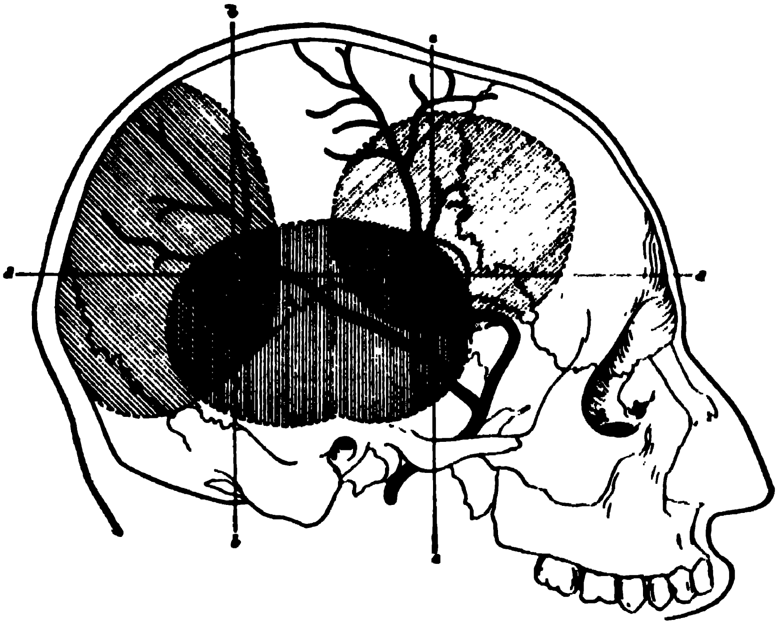

Fig. 40.—The Location of the Hematoma in Hemorrhage from the Middle Meningeal Artery and Its Branches. (Krönlein.)

The operation is very similar to an ordinary subtemporal decompression and will suffice for most of the cases. If an intradural clot is suspected, an incision in the dura or a flap of the dura with its base above is made. Intradural clots can be removed by irrigation with a gentle stream of saline solution. If a pial vessel is bleeding it must be ligated with fine silk. Especial attention must be paid to the under surface of the temporal lobe; the lobe must be carefully raised, and the exposed area cleansed. In this way numerous clots may be washed out from the under surface of the hemispheres.

If there is reason to suspect extra- or intradural bleeding on the other side of the head, exploratory puncture and craniotomy should be performed on the second side, followed, if necessary, by subtemporal craniotomy.

If there is reason to suspect that there is a collection of blood in the hemisphere, the brain must be aspirated according to the general principles laid down in another section of this chapter.

The treatment of hemorrhage of the new-born deserves especial mention. It has been shown that a variety of intracranial injuries may occur during birth, and that in the infants that survive, spastic diplegias (Little's disease), epilepsy, and idiocy are of frequent occurrence. Not a few of these birth injuries are due to the overlapping of the parietal bones during delivery. Bleeding within the dura and into the cortex is apt to occur either from pial veins, tears of the tentorium or laceration of the cortex. Cushing was the first to draw attention to the possibility of saving some of these infants by early operation, and he has reported a number of very successful results after unilateral and bilateral operations. The infants stand the operation remarkably well if little blood is lost. When the scalp is incised each bleeding vessel should be caught as soon as it is cut. The elastic tourniquet should never be applied to the infant's head, because the amount of elastic pressure necessary to control bleeding will force the brain out of the skull as soon as the dura is incised.

After a large flap of the soft parts has been outlined, the bone is rapidly cut with a pair of heavy curved scissors, and the dura incised parallel to the incision of the bone. Clots are removed from the surface of the brain by gentle sponging and by irrigation with saline solution. The dural incision is accurately closed, and the bone flap returned into place and the scalp sutured. If there is reason to suspect bleeding on the opposite side, aspiration is done, followed, if necessary, by exposure of the brain on that side.

The suggestion has often been made to attempt the operative relief of non-traumatic intracerebral hemorrhage, of the ordinary apoplexy, and Horsley is an enthusiastic advocate of such a method of treatment. Up to the present time, however, the results of operations have been very poor.

Finally, in the absence of a large collection of blood, a subtemporal decompression may be of benefit in relieving the symptoms of increased intracranial pressure due to multiple small hemorrhages in and around the brain.

The results of operations for intracranial hemorrhage depend very much upon the time when the patients have been operated upon and the presence or absence or complicating injury to the brain itself. Custodis collected 108 cases of injury to the middle meningeal artery which were subjected to operation with 86 recoveries and 22 deaths, a mortality of 20.37 per cent. The mortality of intradural hemorrhage with operation is higher—of 166 cases collected by Henschen, 53 died, 31.9 per cent.

CRANIOTOMY FOR EPILEPSY

Convulsive attacks occur in a large number of intracranial conditions and the removal of the cause is often followed by a cessation of the convulsions. Thus the extirpation of a tumor from the Rolandic area, the emptying of a cyst in a cerebral hemisphere, or the removal of a clot from the cortex will often remove the irritation which causes the cortical discharges.

Aside from these and similar conditions, epileptic convulsions may follow a cranial injury or a fracture of the skull, or they may appear without any known cause. These convulsions are either generalized, affecting both sides of the face and all the extremities, or the attacks may affect only one side of the body or part of one side. These latter attacks may regularly begin in one side of the face or one extremity, and then spread to the other limb and to the face on the same side, or remain localized in the one limb. This is the type which, since the classical description of Hughlings Jackson, we know as "Jacksonian epilepsy."

Many attempts have been made to benefit the so called idiopathic generalized epilepsy by operative methods, and a large variety of procedures has been recommended. Most of these methods have been based upon the principle of decompression; by means of large openings in the cranial bones the surgeon attempted to relieve the convulsive attacks.

The results of all of these operative procedures have been poor, and, in the large majority of the cases, the attacks were either uninfluenced by the operation or returned after a short time.

A large number of operative procedures have been suggested and recommended for the surgical treatment of epilepsy outside of the operations upon the brain above mentioned. Many of these have been founded upon insufficient data, and have proved futile. Among these may be mentioned resection of the cervical sympathetic which was once very highly recommended by Jonnesco. The good results at first reported were undoubtedly due to the fact that epileptic attacks will often cease for a few months after any operation.

I do not believe that we are justified in recommending any kind of operative interference in generalized idiopathic epilepsy.

If, on the other hand, the convulsive attacks regularly begin in one set of muscles and then affect other muscles in succession, we are justified in the assumption that the convulsive attack is caused by an irritation of the cortical center which controls the movements of the group of muscles that is first affected; an exploration of this area in the cortex is justifiable, with the hope that either a remediable lesion will be found, or that, by excision of this area, attacks will be prevented.

Operative interference may, therefore, be required in the following cases of Jacksonian epilepsy:

1. *Post-traumatic.* Epileptic convulsions are very frequent after frac-

tures of the skull, and the operation may reveal adhesions between the cortex and the dura, or other cortical changes.

2. *Idiopathic forms*, where there is no known cause for the attacks, but where their localization makes an exploration of the affected area justifiable, in spite of the fact that the convulsions form the only symptom. In a certain number of these cases, an organic disease, such as a small neoplasm or cyst or a localized process in the pia mater, may be discovered at operation. In most of the patients, no changes will be found, with the exception of the edema of the pia mater which occurs after convulsive attacks and which must not be mistaken for the cause of the convulsions.

As the results of operative interference in all forms of Jacksonian epilepsy in which no local lesion is found are very poor, the surgeon should be very conservative in his indications for operative interference.

The results of operations for posttraumatic Jacksonian epilepsy in which depression of bone, a cyst, or a bony splinter pressing upon the cortex are found, are much better than those in which no lesion is discovered. The brain should be exposed through a large osteoplastic flap, and the dura incised. Depressed bone is removed, adhesions between the cortex and dura are separated, cysts are opened, and the cortex is excised if it appear diseased. The edema of the pia which is so often present is relieved by numerous small needle punctures.

If adhesions exist between the dura or soft parts (if there is a defect in the dura), these should be divided, and a piece of Cargile membrane used to cover the exposed portion of the cortex.

If the changes in the cortex are only slight, or if no changes are visible to the eye, excision of the cortex over the motor area corresponding to the parts that are primarily attacked by the convulsive attack is indicated. By means of a unipolar electrode the location of the area to be excised is first determined (see Faradization of the Cortex). The pial vessels over this area are then ligated, and the cortex to a depth of 0.5 to 0.75 cm. excised with a small scalpel aided by small curved scissors. The bleeding is never great and is easily controlled by means of pressure with cotton or sponges wrung out in hot salt solution. The area of cortex in which the excision has been made is then covered with a small piece of Cargile membrane, and the dura closed in the usual manner.

I do not think that the majority of reports of results obtained give us the proper idea of what is really accomplished by operations for Jacksonian epilepsy where no distinct lesion such as a tumor or cyst, depressed bone or a splinter of bone in the cortex is found. Any operative procedure is apt to cause a cessation of the convulsive attacks for a time, but in a few months or one or two years later, the attacks return. We can therefore consider as cured only those patients in whom no attacks have occurred for a number of years.

If we exclude cases of reflex epilepsy in which a cure followed an operation in other parts of the body than the brain, the best results that we may expect from operations for traumatic cortical epilepsy are about 10 to 15 per cent. of definite cures. Tilman collected 260 cases, with 11 per cent. of cures for longer than three years, 10.8 per cent. for over one year, and 12.8 per cent. for over one-half year. Improvement occurred in about 15 per cent., and death in 6 per cent. Of 20 cases of his own, 4 were well for more than three years, 3 for more than two years, 3 for more than one year, and 2 for more than one-half year. Oppenheim states that we can expect only about 6 per cent. of cures, no matter what the nature of the operation.

The operation should be done as early as possible, before the cortex has undergone "epileptogenic changes."

It is in no way proven that increases of intracranial pressure may be the cause of epileptic attacks, and therefore there is no justification for the attempt to improve epilepsy by means of decompressive operations as advised by Kocher.

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CHAPTER XI

THE TECHNIC OF CEREBRAL SURGERY

JAMES H. KENYON

It has been my privilege to have worked with the late Dr. Frank Hartley (22), particularly in connection with surgery of the central nervous system, and the following is a description of the principles and methods employed.

GENERAL CONSIDERATIONS

The ideal of the surgeon should be to render exploratory operations on the head as simple of performance as an exploratory laparotomy, with as satisfactory an exposure and accompanied by no more disturbance to the patient, either immediate or remote.

The aim of the surgeon in cerebral surgery should be directed toward (1) the lessening of shock by diminishing hemorrhage and shortening the time of operation, which is even more important in surgery of this region than elsewhere in the body.

(2) Obtaining a good generous exposure of the operative field so that, no matter what condition is found, it may be dealt with easily and thoroughly without undue manipulation or retraction of the brain and without delaying the operation by further bone removal. This must be done in such a manner as not to interfere with the subsequent complete restoration, as far as possible, of the protecting cranium, for which purpose an accurately fitting osteoplastic flap is made of such a size and shape as to offer the best exposure, with sufficient blood supply to insure, after its return and careful suture, a perfect primary union. In certain cases it may seem best to remove part or all of this bone, but, even so, the initial cutting of it in one piece is quicker and easier than rongeur removal

(3) Selecting a method for making this flap which will lessen, for the operator, the necessary physical work and thus leave him with untired hands for the more delicate intracranial manipulations.

Particular emphasis is placed upon accuracy in locating the intracranial condition by some easily applied method of cerebral topography which will hold good for all ages and races; upon a large generous opening in the skull of such size and location that no further bone removal will be necessary; upon a simple and easy method of cutting the bone which will be safe and efficient under all conditions.

Simplicity in the armamentarium is particularly desirable, but it is not advisable to obtain this by sacrificing efficiency under all the varied conditions that arise. For example, many methods excelling in simplicity and efficiency in many cases will prove unsatisfactory when a thick or very hard skull is encountered.

Various accidents are recorded during the use of almost every known method. For example, chisels which require undue pounding and thus increase the shock, may penetrate too deeply. Gigli saws may damage the dura. Circular saws with a guide between the dura and bone may catch in adherent dura and damage it. Circular saws with circular guards may cut the dura if the operator has not made holes enough to give him an accurate idea of the thickness of bone along each side which has to be cut. Drills which are supposed to lock have failed to do so and have penetrated too deeply with unfortunate results. The cutting tooth on the slot-forming forceps, working from within outward, has snapped off and the piece subsequently found embedded in the brain.

One must then select some method of cutting the bone which involves the minimum risk with the maximum efficiency under all conditions.

METHODS OF CUTTING THE BONE

Chisel.—Bone removal with the chisel, either entire or as an osteoplastic flap, was employed at one time, but for many obvious reasons has been abandoned, except, of course, in mastoid operations.

Trephine or Burr, Followed by Rongeurs.—In cases where the bone is not to be saved, one or more openings are made with a burr or trephine near the center of the portion to be removed and the surrounding bone is cut away with rongeur forceps to the desired extent. This method is quick, simple, and safe, provided the bone is not thick or hard, in which case considerable time and physical labor are required. This manual work tires the operator's hand and renders more difficult the subsequent delicate intracranial work. A bone defect is left, which, except in the cases requiring a decompression, is not desirable and may require a subsequent operation for its closure. A disadvantage in using this method is that one is rather influenced to make an insufficient exposure.

Gigli Saw.—The Gigli saw furnishes a very good method of making an osteoplastic flap. Several holes are made around the periphery of the flap on the piece of bone to be removed, either with burrs, drills, or a small trephine. A suitable guide, a watch spring or probe, is then passed from one hole to the other between the dura and the skull. This guide is threaded to a Gigli wire saw which is pulled through and is then made to cut the intervening bone from within outward.

This is a very good method in that it gives an accurately fitting bone flap, but it has the objections of being slow, the saws are very apt to break, and often considerable difficulty is experienced in passing the saw from one hole to the other, particularly if the dura is adherent to the bone. In this case the saw may pass under the dura and cut it. (A grooved protecting guide should be used.—EDITOR.)

Trephine or Burr, Followed by Slot-cutting Forceps. Another method of forming an osteoplastic flap is to make, with a trephine or burr, 3 or 4 holes outlining the opening and then with an especially constructed forceps to cut a slot between them. A short portion of bone, generally opposite the uncut side or hinge, is cut with a Gigli saw in order to give a better fitting flap.

There are several makes of these forceps which are of similar construction in that they cut from within outward. They are simple and safe but leave a wide slot with a poorly fitting flap. In thick hard bone their operation is difficult and the inner jaw has been known to break with subsequent injury to the brain from the fragment flying inward.

These slot-cutting forceps are named from their various designers, De Vilbiss, Dahlgren, Blaisdell, Hudson.

Fraise.—In 1897 Cryer of Philadelphia designed an apparatus, a fraise, similar to a twist drill with spiral blades which, when revolved by a flexible cable or pulley and belt, and pulled sideways, would cut a slot. The lower end rested in a metal shoe which formed a depressor for the dura and was connected to the handle by a narrow piece of metal. In about 1900 Sudeck devised a fraise with a similar cutting principle but with a small metal button firmly fastened to the tip, which served as a dural depressor and protector. This was operated by means of an electric motor and a flexible shaft. Bercut and Borchardt in 1906 made modifications of the fraise.

METHOD OF USING THE FRAISE. The fraise is introduced through a hole in one corner of the flap and, by pulling it in the proper direction, is made to cut a slot from this hole to a similar one made in the other corner of the flap, where the instrument is lifted out. A slight up-and-down movement at right angles to the surface facilitates the cutting. The fraise requires considerable power to operate, becomes hot quickly, and cuts a wide slot, so that unless that portion of the bone opposite the hinge is cut in some other way, as with the Gigli saw, the flap will swing in and rest on the dura rather than the surrounding bone. With a thick hard bone the cutting is difficult, adherent dura and uneven bone are troublesome, and the dura, at times, is caught and torn.

Circular Saw.—There are various circular saws, some with an adjustable shoe, which, coming in contact with the outer surface of the skull, regulates the depth to which the saw will cut. Powell and Marsland saws are examples of this type. There are still other circular saws, as the saucer-like one of Van Arsdale, with a guard following the saw and extending under the bone to protect the dura. There are also the Sudeck and the Doyen circular saws.

A rapidly revolving circular saw impresses many surgeons as being very dangerous, not only to the operator and assistants, but also to the patient. A brief familiarity with its use, however, soon convinces one that, with any care at all, there is really no danger. There is no danger to the operator, as his hands are occupied holding the instrument and cannot come near the saw. The assistants have only to keep their hands away, never to sponge when the saw is running, and to hold the retractors from the end and not up close to the wound. As to the patient, properly placed retractors will protect the soft parts from damage. An accurate knowledge of the thickness of bone to be cut and the placing on the saw of a suitable guard which will not permit of its cutting all the way through by 1 to 2 mm., prevent damage to the dura or brain.

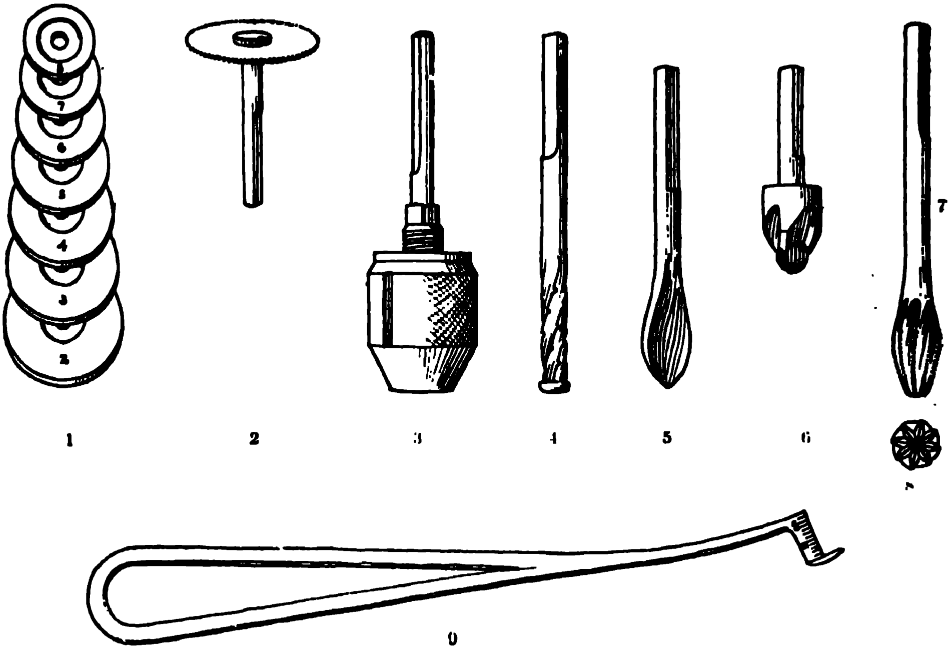

FIG. 1.—WASHERS, DRILLS AND OTHER INSTRUMENTS FOR THE CIRCULAR SAW. 1, Washers or guards for the circular saw. Each stamped with a number from 2 to 8 inclusive. This number shows in millimeters the depth the saw will cut when that particular washer is attached to it; 2, circular saw, 3.5 cm. ($1^{3}/_{8}$ inches) in diameter; 3, chuck for holding small drills; 4, fraise with serrated blades and button for protecting the dura; 5, a Doyen cutter for starting the holes; 6, spherical burr mounted on a conical one to be used after for reaming out the holes to permit the insertion of the measure; 7, Hartley-Kenyon burr with which the holes may be started and completed, thus eliminating the two cutters previously used; 8, end view of 7: 9, measure, graduated in millimeters, for measuring from within outward the skull thickness at the holes.

All shoes, guards, or protectors sliding between the dura and the bone have been abandoned because they may catch in adherent dura and damage it or become jammed on uneven bone. Furthermore they are unnecessary.

Of all the various methods we have tried, the one which is the most satisfactory, fulfilling the greatest number of requirements under all conditions, whether cutting large or small openings, whether the bone is to be removed and not replaced, or during the formation of an osteoplastic flap, regardless of the thickness or density of the bone, is the Doyen circular saw and washers (Fig. 1, Nos. 1, 2), the Doyen measure (Fig. 1, No. 9), and, for making the holes, a burr designed by the late Dr. Frank Hartley and myself (Fig. 1, Nos. 7, 8).

THE MOTOR.—The power to operate these burrs and the saws may be obtained from an electric motor, 1/6 to 1/4 horse power, mounted on a stand or table, and a flexible cable, either of twisted wire or one composed of links, with a flexible metal sleeve. The cable may be rendered aseptic by wrapping it in a sterilized bandage, or, better still, by sterilizing it in the steam sterilizer with the dressings or by boiling it with the instruments.

The cable must have considerable strength or it will twist off, coil up, or chatter. A cable of the proper strength is heavy and stiff. A change of the operative field or of the position of the operator will often require a complete change of the motor, table, etc.

This combination of table, motor and cable has many objections. To do away with these undesirable features, I have devised a small motor which can be held in the operator's hands with a switch control under his finger, and with the cutting tools connected directly to the motor shaft. It is so constructed that the outside shell with the wire can be removed, boiled, and reassembled. This motor is so wound that it will run on the standard commercial current of 115 volts, either direct or alternating, or it may be wound to run on a storage battery of from 6 to 12 volts.

These motors are made in two sizes. One type weighs, complete with the handle, about 9 pounds and runs at a speed of from 3,600 to 6,000 revolutions a minute, and develops about 1/8 horse power. The other type is lighter, weighing about 6 pounds complete, and runs somewhat faster. It develops about 1/12 horse power, which sufficient to operate the burr and saw.

The actual working time of these motors is so brief that they can be tightly enclosed in a metal case without danger of overheating. The 10 feet of wire which is connected to the motor is the ordinary flexible electric light wire, and can be boiled repeatedly, preferably in plain water without soda, and, even while wet, it can be used without any trouble. Another satisfactory way of sterilizing the removable casing and wire is to put them in the steam sterilizer, and they will then come out dry.

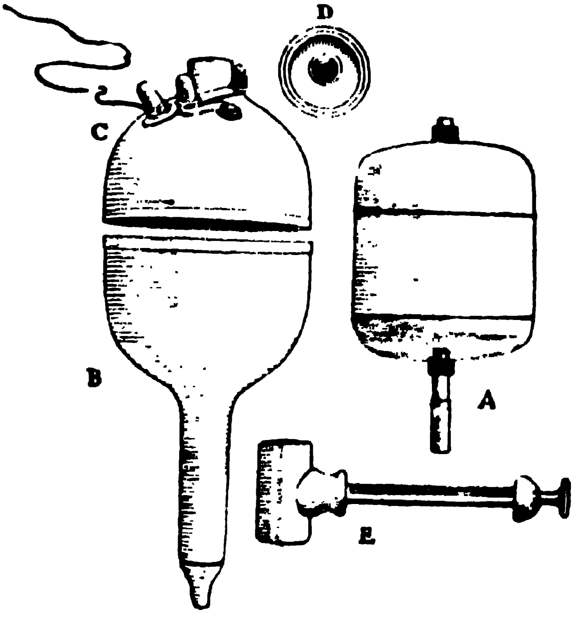

FIG. 2 - ELECTRIC MOTOR. A, Motor, B, casing, C, casing; D, knob; E, handle. weight complete, about 9 pounds; length, 11 inches; diameter, 4 inches; speed, 2,000 to 4,000 revolutions per minute; shunt wound, direct current, 115 volts; also direct current, 6 volts, 12 volts, and 220 volts; also may be used on alternating current by shifting the brushes. Another type has a universal winding which operates either with a direct current or an alternating current. Power about 1/8 horse power.

ASSEMBLING OF MOTOR AND CASING.—The casing is put on the motor as follows: The doctor who is cleaned up and ready to lay out the instruments, dries the interior of the casing with a sterile towel, tests the binding posts to see that they are tight and that there are no loose wires. The body of the motor is placed on a folded sterile towel held in his left hand, the end A (see Fig. 2) being held upward. The shell, B, is then screwed on as far as it will go or until a mark on the casing and one on the motor are in line. The motor is now held in the right hand by this sterile portion, and the soiled towel in the left hand thrown away. The other half of the sterilized casing, C, is taken in the left hand and slipped on, and held in place by screwing down, with the left hand, the knob, D.

Two or 3 feet of the sterilized wire is kept on the table with the motor; the rest of it is dropped to the floor, where someone connects it with the wall socket or with a drop light socket, which is less in the way than an overhead connection.

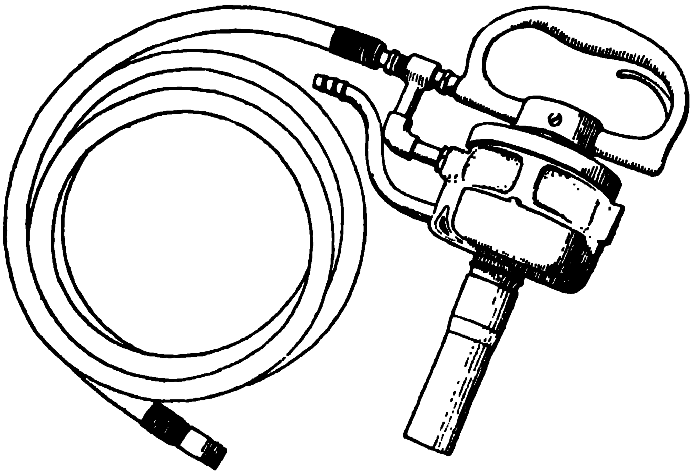

FIG. 3.—COMPRESSED AIR MOTOR FITTED TO USE SAME CUTTERS AS ELECTRIC MOTOR. Weight about 6 pounds. Requires 80 to 90 pounds air pressure. Motor and hose can be boiled or sterilized in the steam sterilizer.

Every exposed part of this casing and wire is sterile and the casing is watertight so that nothing can work down from the running motor and contaminate the operative field.

TECHNIC.—During the operation the motor is held as follows: The adjustable handle, E, placed at right angles to the long axis of the motor, is held in the right hand; the knob, D, is grasped in the left hand, and the left thumb and index finger manipulate the switch which controls the current. In order to give the flap the proper bevel it will, at times, be necessary to reverse the hands, the knob, D, being then held in the right hand. Instead of this electric motor, one driven by compressed air may be used (Fig. 3).

For boring the holes we have devised a special cutter, shown in Figure 1 (7, 8), which is so constructed, with a rounded tip and diverging serrated cutting blades, that it penetrates slowly and when it is nearly through, with bone only the thickness of an egg shell to be cut, it makes a characteristic sound and the operator feels the sudden diminution in the resistance at the cutting end. It is then withdrawn and the hole inspected.

The dura may be seen at the bottom undamaged. Generally, however, a thin layer of cracked bone hides the dura and protects it from injury. Even if this warning sound is not heeded, and the burr is allowed to cut deeper, the dura will still be unharmed as the tip of the burr is so made that it can turn for some time on a soft yielding substance without cutting it.

After the holes are drilled (Fig. 4) at the corners of the flap and along the sides, the thickness of the skull is measured at each opening (Fig. 1, No. 9, Fig. 5). If this varies more than 2 mm. between two adjoining holes, another

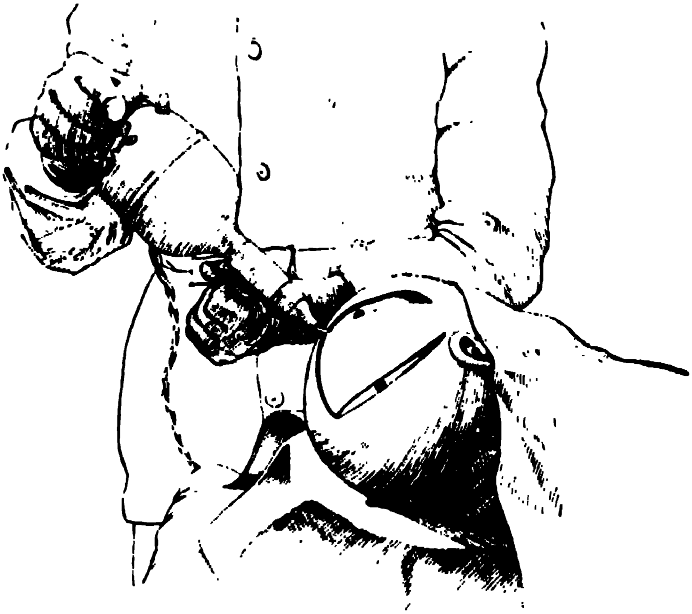

FIG. 1. DRILLING THE HOLES.

hole is made. The metal washers or guards (Fig. 1, No. 1) are stamped with numbers from 2 to 9 which indicate in millimeters the depth of the saw exposed for cutting when that particular washer is fastened to it.

One of these washers is selected of such a size that when it is applied to the saw and the saw made to cut between any 2 holes, there will remain uncut bone between the saw teeth and the dura, about 2 mm. in thickness. The washer rides on the bone and the saw cannot possibly cut any deeper (Fig. 6).

To insure a better fitting flap 1 or 2 sides are cut on a bevel. When the variation in thickness is slight the tilting of the saw from a right angle to the surface to a 45° bevel will vary the depth of cutting and obviate the changing of the washer (Fig. 7).

The uncut inner table, varying in thickness from 1 to 2 mm., is cracked by inserting in the saw cut at the holes a thin osteotome, which is held nearly

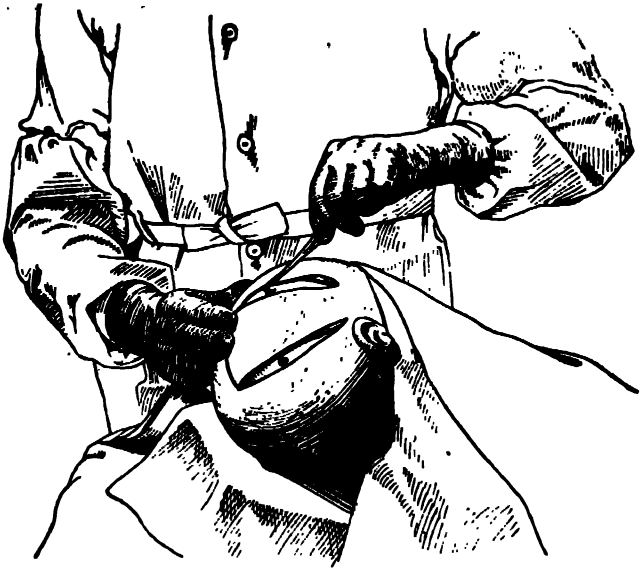

FIG. 5.—MEASURING THE THICKNESS OF BONE AT HOLES. A rough sketch of the shape of the flap should be made either by the assistant on a sterile slate or a sterile pad, or by the anesthetist, and the numbers showing the skull thickness marked down at their proper places. This is of great aid in the subsequent selection of a suitable washer for the saw.

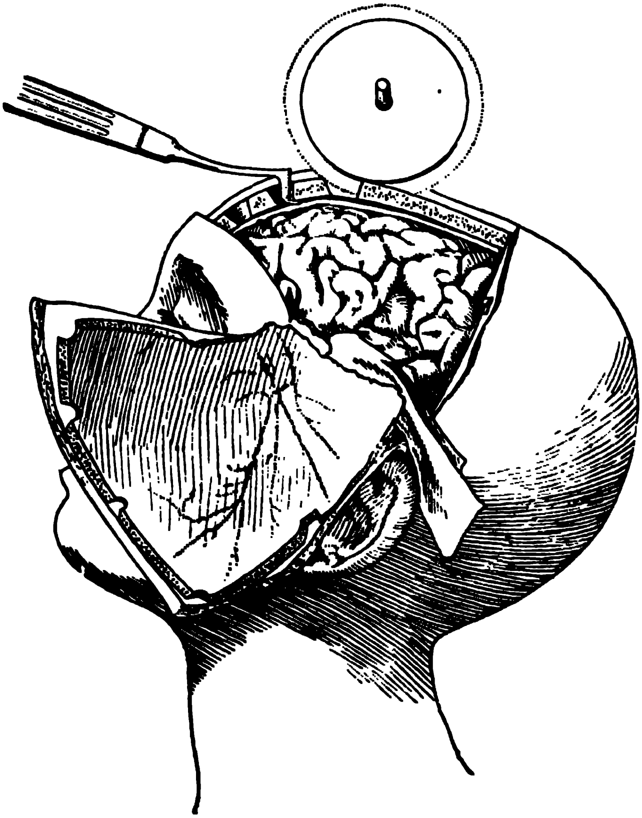

FIG. 6.—INSERTION OF MEASURE AT A HOLE TO MEASURE SKULL THICKNESS FROM WITHIN OUT. This also shows how the circular washer on the saw prevents its cutting entirely through.

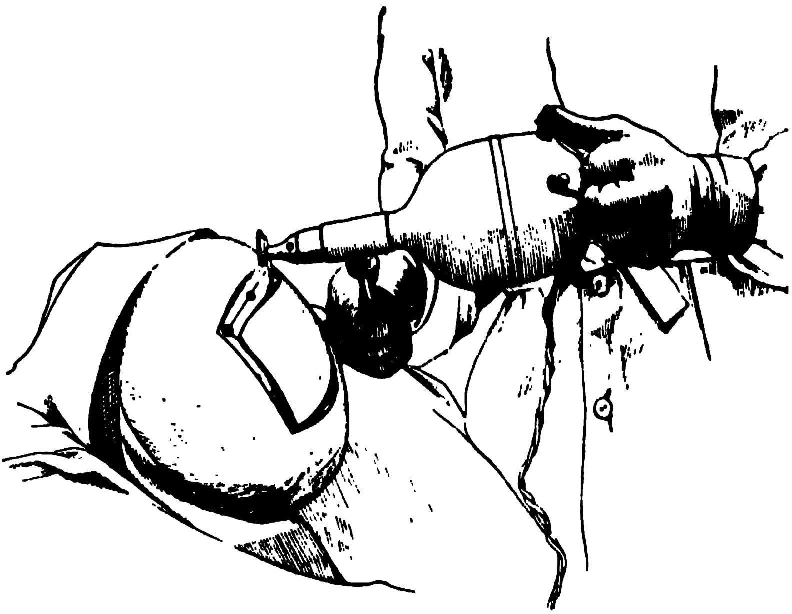

Fig. 7.--Method of Holding Motor. The circular saw is cutting at a bevel to the skull surface The washer is resting on the bone.

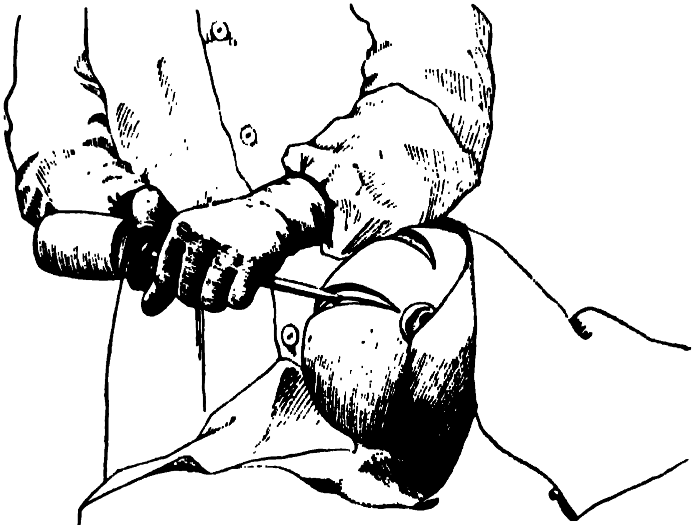

Fig. 8.—Cracking the Thin, Uncut Bone at Bottom of Saw Cut. A thin osteotome is inserted in the saw cut at the holes, held nearly parallel to the surface, and tapped with a mallet.

at a tangent to the surface rather than at right angles, and slightly tapping it with a mallet (Fig. 8).

This cracking with the osteotome is done at each hole, particular attention being paid to the holes where the uncut skull is the thickest. With two periosteal elevators or chisels, the flap is pried up, beginning at the side opposite the hinge, at which point pressure is made to aid in breaking the bone (Fig. 9).

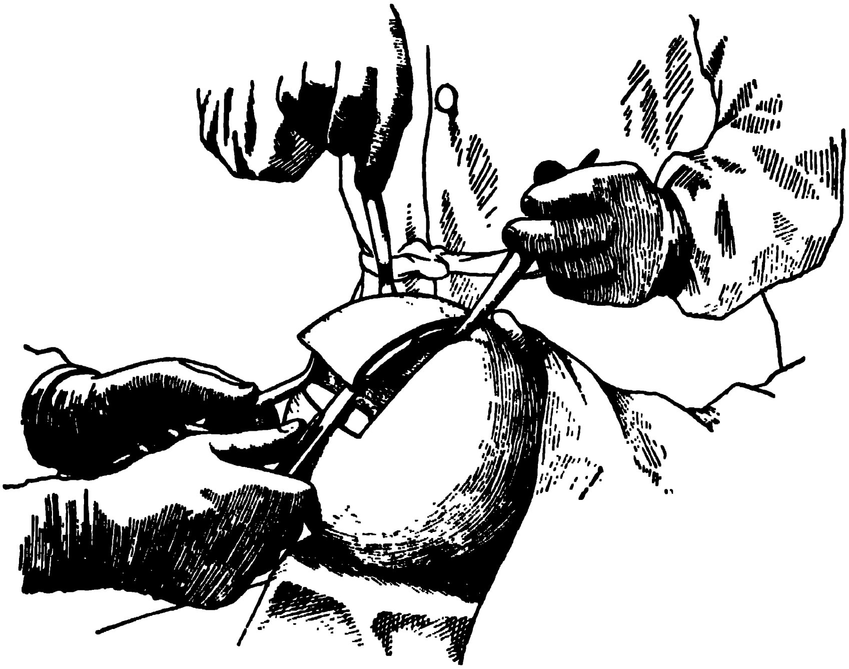

Fig. 9.—Prying up Flap with Periosteal Elevators.

The flap is turned down and wrapped in a piece of gauze or a towel wet in warm salt solution, care being taken not to strip the bone from the soft parts.

PREPARATION OF THE PATIENT

General.—It is especially desirable that every head case be examined most carefully and a written report made, not only by a neurologist, but also by an oculist, who should test and make careful note of the fundus of the eye and the extent of the visual fields.

The patient should be under observation for a week or so, and during this time repeated and careful record made of all the symptoms. A record of the blood pressure should be taken at frequent regular intervals. Bowels, skin and kidneys are regulated and put in the best possible condition. Drugs should be discontinued.

Local.—It is better to shave the entire head in nearly every case rather than just the region to be operated upon. This may be done the day before the operation, and, at the same time, the landmarks for the cerebral localization may be marked on the scalp with carbolic acid fuchsin.

The final preparation, when the patient is on the operating table under the anesthetic, is to paint the scalp thoroughly with full strength tincture of iodin. As soon as this has dried, it is rubbed off with 95 per cent. alcohol. Some operators prefer not to rub off the iodin. There are many variations in the local skin preparation which may be mentioned. The scalp may be first rubbed with benzin and then painted with tincture of iodin. Or tincture of green

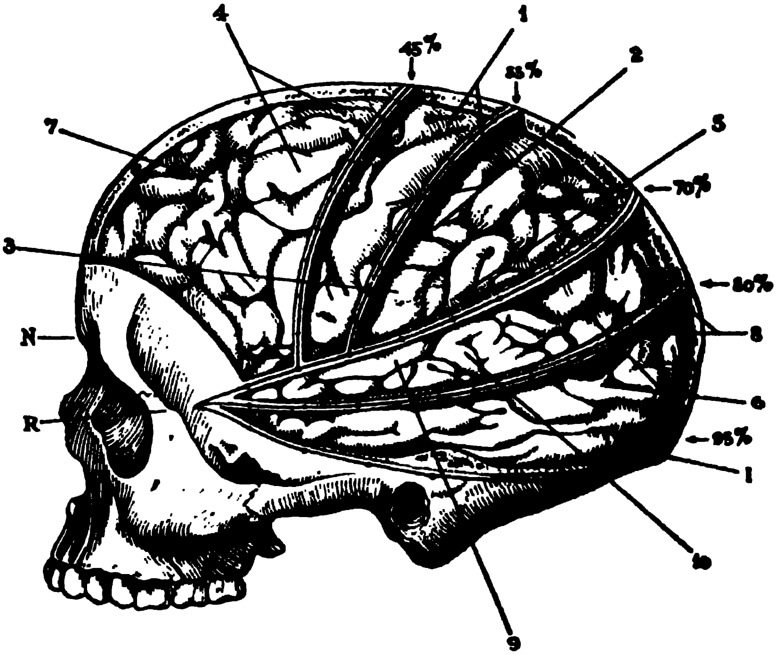

FIG. 10.—CHIPAULT CRANIOCEREBRAL TOPOGRAPHY.

N, Nasion or nasofrontal suture. I, inion or external occipital protuberance; R, retro-orbital tubercle. 45 per cent, Precentral point; 55 per cent, Rolandic point; 70 per cent, Sylvian point; 80 per cent, temporosphenoidal point; 95 per cent, lateral sinus point.

1, Motor and sensory disturbance, lower extremities; 2, motor and sensory disturbance, upper extremities; 3, motor and sensory disturbance, face, tongue, jaw, pharynx, and vocal cords, motor aphasia in right-handed people and vice versa; 4, (a) movements of the body (posterior part of the first frontal), (b) movements of the head and neck (posterior part of the second frontal), (c) associated movements of the eyes and head; 5, tactile and muscular sensibility; 6, hemianopsia and word-blindness, agraphia, and paraphasia; 7, intelligence; 8, storage of visual images (cuneus, lingual lobe and calcarine fissure, which lie in the longitudinal fissure between the 70 per cent and 95 per cent points); 9, audition; 10, images for words heard and musical tones (left side). In this same region on both sides the sensory motor auditory center exists. The internal frontal convolution lies in the longitudinal fissure opposite the superior frontal convolution. The paracentral convolution lies in the longitudinal fissure between the 45 per cent and 55 per cent points. The quadrate lobe lies in the longitudinal fissure between the 55 per cent and 70 per cent points. The cuneus, lingual and fusiform lobes, first, second and third occipital convolutions, are between the 70 per cent and 95 per cent lines.

soap and water may be used, followed by alcohol, then ether, with or without subsequent painting with tincture of iodin. The end results of all these methods seem to be about the same.

CRANIOCEREBRAL TOPOGRAPHY

Craniocerebral topography is of the utmost importance. Some good reliable method should be selected and the scalp marked out according to it as a routine practice in every case. Of course, with the large exposures that are now made, a slight error in the exact location of the lesion and planning the flap is not so detrimental as when a smaller opening was made. To an experienced operator the actual marking on the scalp is not so essential, as his trained perceptions locate very accurately the cortical centers.

However, in obscure cases, where one wishes to identify any particular portion of the cortex to be exposed in the opening, the flap may be swung back in place and the landmarks noted upon it, together with their projection on the brain surface. In cases where, from the general condition, a large opening or the making of a second flap or the added bone removal in addition to the first opening is thought to be undesirable, a good reliable topography is very valuable. The best method we have found is the Chipault method. It is easy to remember, easy of application, and very accurate, regardless of age, race or individual, because of its dependence upon a percentage basis. We have tested it thoroughly for many years in the Operative Surgery course at the College of Physicians and Surgeons, and in all the operations on the living.

THE CHIPAULT CEREBRAL LOCALIZATION

The distance from the nasofrontal suture or nasion, the depression below the glabella, over the sagittal suture to the inion or external occipital protuberance, is measured. (The metric system is the more convenient.) On this line, measuring from before backward, the following percentages of its whole length are marked.

(1) 45 per cent., known as the precentral point.
(2) 55 per cent., known as the Rolandic point.
(3) 70 per cent., known as the Sylvian point.
(4) 80 per cent., known as the temporosphenoidal point.
(5) 95 per cent., known as the lateral sinus point.

Next, the retro-orbital tubercle is located. This is a small process on the posterior border of the upper part of the frontal process of the malar bone, below the external angular process of the frontal bone, and is just about opposite the external canthus of the eye.

A line is drawn from this tubercle to the 70 per cent. point and its distance measured. This marks the Sylvian fissure. This line is then divided into tenths.

The junction of the second and third tenths is joined by a line to the 45 per cent. point. This marks the precentral fissure.

The junction of the third and fourth tenths is joined by a line to the 55 per cent. point. This marks the Rolandic fissure.

The retro-orbital tubercle is now joined to the 80 per cent. point. This marks the superior temporosphenoidal fissure.

The line from the retro-orbital tubercle to the 95 per cent. point marks, in its posterior portion, the lateral sinus.

All these lines are subdivided into tenths for fine localization.

The anterior branch of the middle meningeal artery crosses the second tenth of the three primary lines.

The posterior part of the body of the lateral ventricle may be tapped by inserting the exploring needle in the superior temporosphenoidal convolution at the junction of the third and fourth tenth on this line, at a depth equal to 1/3 of the transverse diameter of the brain at this point.

To explore the descending horn, the needle is inserted in the middle temporosphenoidal convolution directly above the external auditory meatus.

POSITION OF THE PATIENT ON THE TABLE

All head cases should be so placed and secured on the table that the head end of the table can be raised to 25 or 40 degrees.

This position should be such that the operative field is uppermost and conveniently placed for the operator. And this must be obtained without undue strain on the patient's neck or interference with the respiratory function.

For the *frontal* and *anterolateral* exposures the patient should be flat on the back.

For the *lateral* and *posterolateral* exposures, more or less of a side position, with a sufficient number of sand bags under the head to steady it and sufficiently elevate it, should be obtained. To prevent the head from rolling from side to side, the sand bags are placed so as to form a furrow in which the head may rest.

For exposure of the *occipital lobes* or *cerebellum*, the patient is generally placed directly on the face with a large sand bag under each shoulder, in order to lift the chest free of the table and permit of easier breathing. The forehead may rest on an adjustable head piece fastened to the table in such a way that it can be moved in or out, raised or lowered; or the forehead may rest on a separate stand or table placed a short distance from the operating table. The chief object of this arrangement is to facilitate flexing or extending the neck as conditions require, and also to aid the anesthetist.

ANESTHESIA

Ether is given the preference as being safe and easily controlled. For many cases the drop method will suffice, but in others it will be difficult of application. Furthermore, it is often desirable to get the anesthetist really out of the way.

The simplest, and perhaps the best, method, equally satisfactory in all head cases, is nasal anesthesia.

Nasal Anesthesia.—Select a bottle similar to that on the oxygen tank which has a tight-fitting stopper through which pass 2 tubes, one to the bottom of the bottle and the other just through the stopper. Ether to the depth of 5 to 8 cm. (2 to 3 in.) is placed in the bottle and the stopper firmly fastened down with a long narrow strip of adhesive plaster. It is best to have this bottle suspended from the lower bar of the table near the floor, although it may be left attached to the oxygen tank. From the glass or metal tubes in the bottle, 2 rubber tubes long enough to reach the patient with a foot or two to spare, are fastened to the top of the table with adhesive plaster. The short tube, which comes from the top of the bottle, should have a tapering glass or metal connecting tip over which is slipped a soft rubber catheter. The largest catheter which will just snugly enter the nostril is the best.

On the end of the other tube, the one extending to the bottom of the bottle, is attached a cautery bulb or an atomizer bulb or, later on, if occasion requires it, the oxygen tank, a compressed air tank or a rotary blower.

The patient is first anesthetized by the ordinary method, and as soon as he is lightly under, the catheter, still attached to the tube from the bottle, is gently inserted down one nostril. Should this nostril appear to be narrow or obstructed, the other should be tried. While the catheter is being pushed down, the liquid ether in the bottle should be carefully watched, and as soon as the patient's respiratory efforts produce a bubbling of the ether it is known that the catheter has reached the proper depth. The catheter is then secured at this point by passing around it, close to the nose and off on the skin of both cheeks, two long narrow adhesive strips. The length of catheter in the nose is generally about equal to the distance from the anterior nares to the external auditory meatus measured over the cheek.

Now, for a few moments, the mask and drop method plus the manipulation of the bulb may be necessary in order to produce the required degree of anesthesia. After this stage is reached the bulb alone, or, in many cases, the patient's own respiratory effort will be sufficient to preserve a light anesthesia. Whenever the degree of anesthesia is deeper than desired, the glass connecting tip must be removed from the catheter for a time, thus eliminating, temporarily, all the ether. Instead of the bulb the oxygen tank may be connected and a steady flow of oxygen through the ether and then into the pharynx employed. This gives a very even anesthesia with a combination of oxygen and ether which, in many cases, is greatly to be desired, as it corrects any tendency toward cyanosis, which is very apt to cause venous oozing and delay the operation.

FORM OF FLAP

The form of the flap made is generally trapezoidal, with the narrow edge or base in the temporal fossa where the bone is thinnest (1 to 5 mm.), breaks easily and where the blood supply is abundant. In exceptional cases the base may be anterior and get its blood supply from the supra-orbital and frontal arteries, or it may be posterior and be supplied from the occipital artery.

The edge of the flap opposite the hinge may vary from 10 to 12 mm. in thickness, the sides may vary from 5 to 8 mm., and the fractured edge in the temporal fossa from 1 to 5 mm.

The flap is so planned that the suspected lesion will be under its central part.

The size of the flap should be sufficient to furnish a good free exposure, so that all subsequent intracranial steps of the operation may be performed easily without any more manipulation or retraction of the brain than is absolutely necessary.

It should be large enough, and particularly so in the direction of the probable extension of the lesion, so that no further bone work will be required. There are certain conditions, such as those in which the lesion is located near the median line, perhaps encroaching upon the opposite side or presenting on the mesial aspect of the hemisphere, anteriorly, near the vertex or posteriorly, which may require two flaps symmetrically placed, meeting each other about 1 cm. away from the median line (Figs. 15, 16, 17, 21).

This double flap arrangement may be planned at the outset of the operation. Or one flap may be completed, the intracranial condition inspected and, if more room is required, the first flap may be temporarily turned back into place in order to protect the brain and the second flap planned and cut.

CONTROL OF HEMORRHAGE

Hemorrhage from the Scalp.—CIRCULAR TOURNIQUET (Fig. 11).—A narrow rubber band or tube is tightly wrapped around the head just above the supra-orbital ridge anteriorly, as low as possible in the temporal fossa and just below the occipital protuberance posteriorly. To prevent the anterior and posterior portion from slipping down, a gauze bandage, passing over the vertex, is used. A rubber tube provided with a check valve may be employed, and after it has been fastened in place, inflated with an air pump. This is known as a pneumatic tourniquet.

Objections to this type are: the encroachment upon the operative field; interference with the turning down of the flap; and, unless applied with the proper degree of tension, they are very apt to cause venous oozing.

A REGIONAL TOURNIQUET.—Another tourniquet is shown in Figure 12. The head rests on a metal plate with a folded towel for a pad. The plate is deeply notched on its periphery and is securely mounted on a firm pedestal which elevates it about 2 in. above the table.

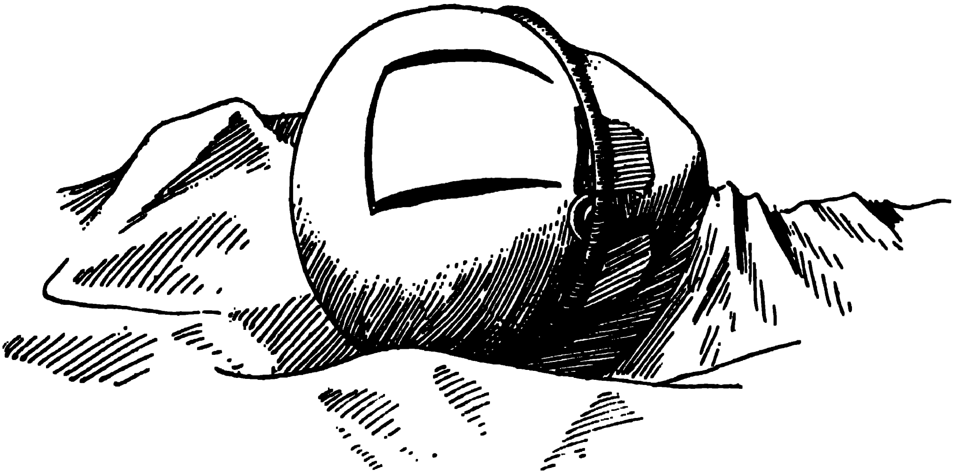

FIG. 11.—CIRCULAR TOURNIQUET. Incision in soft parts down to the bone.

A chain made up of flat links, similar to a sprocket chain, flexible in 2 directions but rigid in the other 2, is passed from one notch over the head to the other notch, with a rubber pad interposed between it and the skin. Two heavy rubber bands, about ½ in. wide and 4 to 6 in. long, are so fastened under the chain and connected with each other that, by spreading the lower one and catching it in the lateral notches, a trapezoidal area is surrounded and its peripheral blood-vessels compressed by these tightly stretched rubber bands. The incision is made just within this area.

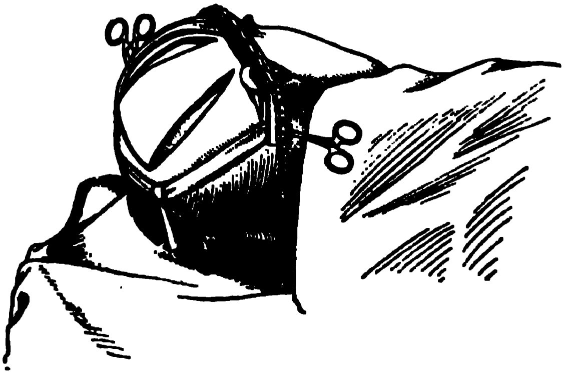

FIG. 12.—TOURNIQUET APPLIED. Incision made down to the bone.

One end of the chain is provided with a long screw, with a nut which has a swiveled handle for turning it.

CLAMP AND SUTURE.—The assistant makes firm pressure with both hands close together. The operator makes the incision between them, extending it completely down to the bone at one cut. The bleeding points on the cut edge are caught with toothed clamps. The tissue near the clamp is transfixed with a curved needle and catgut, and this is tied on both sides of the clamp.

CONTINUOUS SUTURE ALONG CUT EDGE.—Another method is to make a continuous catgut suture along the cut edge—not through the skin—both on the flap side and also on the opposite side. Care must be taken not to make the stitches very far apart and not to pull them very tight, as otherwise the cut edge is distorted, making the subsequent closing suture difficult.

CONTINUOUS SUTURE OF CUT EDGE. Still another method is to place a continuous catgut stitch quickly through the skin and muscle and fascia as soon as the cut is made, around the flap and around the outer margin of the wound. During the final suturing of the flap at the close of the operation this catgut stitch is removed.

HEIDENHAIN STITCH AS MODIFIED BY HACKER AND SENGER.—**This modified Heidenhain stitch is a continuous suture of catgut or silk on a curved needle through the skin down to the bone, completely surrounding the operative field and about 1 to 2 cm. outside of the intended cut. These stitches overlap each other so that every particle of tissue with its blood supply is compressed. After the thorough and careful suture of the flap at the end of the operation, these stitches are all removed.**

KREDEL PLATES.—Kredel plates, with notched ends and grooved upper surface, may be employed by placing a deep suture through the skin down to the bone, the distance between its points of entrance and exit being about equal to that of the plate.

This suture is then tightly tied down on the plate, and compresses the soft parts between the suture below and the plate above. These plates are applied so as to compress the soft parts on both sides of the intended cut. Practically the same result is obtained by the Heidenhain suture.

The combination of the clamp and suture, with a continuous suture when required on the cut edge, avoiding the skin, is very satisfactory, as is also the Heidenhain suture.

Hemorrhage from Bone.—Hemorrhage from the bone is controlled by Horsley's bone wax, which is firmly pressed against the bleeding area by the finger or a piece of gauze or some broad flat instrument. A small piece of muscle bordering on the incision may be cut off and used in much the same manner as the wax. The end of an artery clamp or the rongeurs may be used to obliterate the bleeding point in the bone, some of the bone being crushed in or bitten away for the purpose.

A pointed piece of sterilized wood, such as a toothpick, may be crowded into the bleeding opening in the bone.

Hemorrhage from the Dura.—The bleeding point on the dura is controlled by passing a fine catgut or silk suture on either side of it, using a fine curved needle and being careful to avoid injuring the cortex.

When the dural flap is being made and a vessel crosses the line of incision, a very good method is to make the incision up to the vessel and then carefully pass the fine curved needle with catgut or silk from within outward. By using this method there is no danger of damaging the cortex. Still another method is to cut completely across the vessel, clamp it with a fine clamp, and then pass the needle and tie it off. *The transfixion is quite essential to prevent the ligature from slipping.*

Hemorrhage from the Cortex and the Brain.—Bleeding from the surface of the brain may be controlled by putting over the bleeding point a very small piece of muscle and leaving it, a small piece of absorbent cotton or gauze saturated with vaselin, or Cargile membrane. Adrenalin on gauze or cotton and applied over the bleeding point is sometimes serviceable.

The very slightest pressure, either with an instrument or the gloved finger, with or without the interposition of gauze, cotton, or muscle, will suffice.

Elevation of the head end of the table and the administration of oxygen, if the patient is cyanosed, also tend to lessen the hemorrhage.

Hemorrhage from the brain substance following the removal of a tumor may be controlled by a packing of vaselin gauze, a large piece of muscle with the fascia attached, or a large piece of fascia packed down into the space left by the tumor. For this purpose a portion of muscle and fascia has been taken from the thigh just previous to the time when it was required.

Absorbent cotton may be pressed down into the bleeding cavity.

If the bone has been removed, the scalp may be turned back to its normal position and pressure made on its outer surface, thus crowding it down into the opening. It may be held in this position while it is being sutured in place.

As it is advisable in clean head cases to avoid, as much as possible, drainage and packing which subsequently have to be removed, the hemostatic measures to be preferred are those which completely check the bleeding before the flap is returned to its place. In cases with a pliable flap external pressure may suffice.

OPERATIONS FOR TUMORS OF THE BRAIN

Removal of Tumor.—Before removing any portion of the brain which is more or less vascular, it is advisable to surround it with several interrupted sutures of fine catgut, so placed as to control as much of the blood supply to that area as possible.

Having controlled the vessels supplying the area to be removed, a spoon of suitable size—a coffee spoon, teaspoon, or tablespoon—may be used to scoop out the mass. Or, before this is done, a clean cut with the scalpel can be made at right angles to the brain surface. This facilitates the use of the spoon.

The removal of a growth below the cortex necessitates, first, its exposure by making an incision through the summit of a convolution, always at right angles to the surface, then gentle retraction with broad flat retractors, then the careful removal of it with a suitable spoon or scoop.

As an adjunct to sponging, to give a clear view of the vascular, deep-seated tissues with slight macroscopic differences between normal and pathological structures, and to lessen traumatism of the delicate brain substance by diminishing the amount of sponging, the use of a small, soft metal tube, about 3 to 5 mm. in diameter, bent to a suitable curve, and connected with a continuous suction apparatus, has been of great value.

Owing to the friable nature of many of these tumors, an appropriately selected glass tube or cup, as designed by Fedor Krause, to which a suction tube is applied, makes an excellent retractor. The method of obtaining the suction is described in Vol. I, Chapter VII.

Two-stage Operations.—If the first part of the operation, the making of the opening down to the dura, has been unusually severe and the patient has shown the effects of it by an increasing pulse rate and lowered blood pressure, the safest procedure is to leave the dura uncut, to suture the flap back in place, and, after 5 to 10 days, complete the operation.

If there is not much increased intracranial pressure, the dural flap may be cut and a careful note made of the condition found, and all points noted which might be of value during the second operation. The dura and soft parts are then closed and the second stage done 5 to 10 days later.

The dural flap in cases with marked intracranial tension should be quickly made and firm steady pressure with moist cotton applied upon the brain surface to prevent laceration of and hemorrhage into the cortex from too sudden bulging.

In cases in which the two-stage operation is to be performed the dural flap is not sutured but merely laid back in place over the cortex and part or all of the bone flap removed in order to give the benefit of the decompression and the scalp carefully sutured. The second stage may be done at a later time.

When the dura on exposure is found to be exceedingly tense and the skull opening has been made over the speech area or important motor area, rather than run the risk of producing paralysis, the decompression opening should be made over some less important point, either posterior to the Sylvian fissure or on the opposite side of the head.

After a week or two, when the intracranial pressure has been diminished, one may proceed with the second stage of the operation. Very light general anesthesia or local anesthesia, just sufficient to permit of division of the soft parts, is all that is necessary for this second operation, as the deeper structures are more or less devoid of sensation. In certain cases the lateral ventricle is tapped to reduce the pressure sufficiently to permit of a dural suture. Dr. Harvey Cushing recommends a subtemporal decompression below and behind the Sylvian fissure on the side opposite the tumor as a preliminary to the operation for its removal, particularly in left-sided tumors with marked increased intracranial pressure where the sudden protrusion might cause cortical and subcortical laceration and hemorrhage with paralysis of arm, leg or speech.

Final Treatment of Dura and Flap.—DURA.—After the intradural part of the operation has been completed, the dura is carefully sutured back into place, using fine silk or catgut either interrupted or continuous.

Where there is much increased pressure it may be possible to suture the dural flap on one side only, and this should be done on the side over important centers so that they may be covered as much as possible by intact dura. In other cases the tension may be so great that no suturing of the dura can be done and it can only be smoothly laid back into place over the brain.

If there is uncontrollable oozing and, owing to the increased intracranial pressure, the dura cannot be sutured, it may be advisable to remove the dura entirely, as in these cases it seems to act as a framework for clot formation.

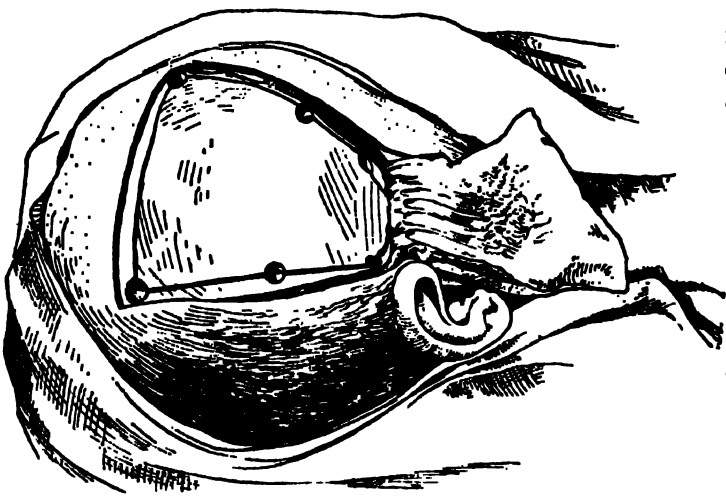

FIG. 13.—SOFT PARTS STRIPPED OFF TO SHOW ACCURATE FIT OF BONE FLAP.

Instead of a flap, in still other cases, radiating incisions are made in the dura and no attempt made to unite them.

BONE.—The entire bone flap is replaced or, according to the degree of decompression desired, part or all of it is removed.

The fit is so perfect that it rests on the surrounding bone on every side and cannot be driven down onto the brain. No drill holes or suturing of the bone are necessary, the closure of the soft parts being sufficient to hold it in place (Fig. 13).

SOFT PARTS.—The soft parts, with or without the adherent bone, are carefully sutured into place. A row of interrupted, buried sutures, either of chromic or plain catgut, unites the muscle and fascia. The skin and subcutaneous tissue are sutured with an interrupted or continuous stitch of silk or catgut. A very good method is to use an interrupted suture of fine silk through everything down to the bone, making the stitches about 1 cm. apart.

After the scalp is completely sutured, firm pressure is made over the suture line and the tourniquet or the Heidenhain stitches removed. A firm gauze dressing, zinc oxid adhesive plaster and a gauze bandage are applied, and sometimes a starch bandage is placed over these.

The head of the bed should be elevated if the pulse will permit.

EXPOSURE OF VARIOUS REGIONS OF THE BRAIN

Exposure of Frontal Region.—Frontal lobe lesions involving the anterior part of the first, second and third frontal convolution or encroaching upon the posterior part of the first, second and third or ascending frontal convolution, in which, in addition to frontal symptoms, there are added, gradually, motor disturbances involving the trunk, head, neck, eyes, or speech, are exposed by the flap shown in Figure 14.

The incision commences 1 finger's breadth from the median line midway between the glabella and superciliary ridge. It passes outward parallel to this ridge until the temporal ridge is met, where it descends toward the zygoma, ending just above it.

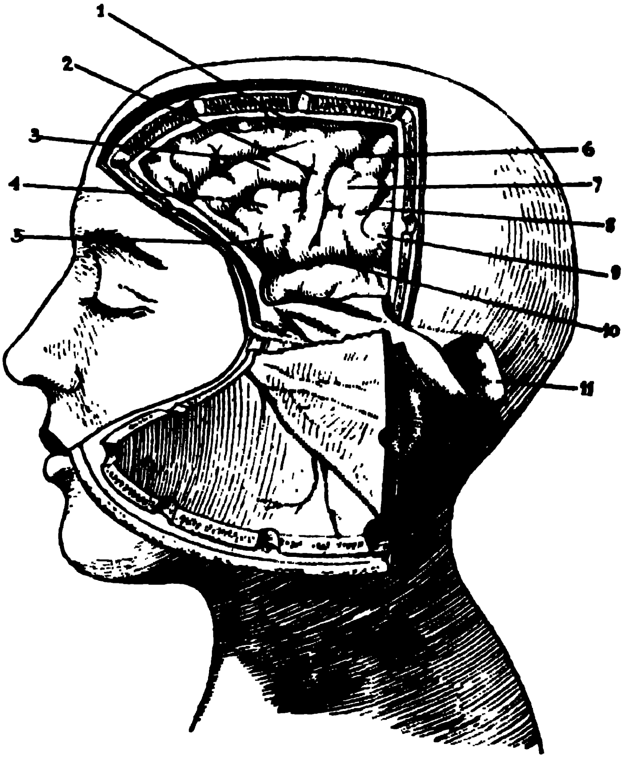

FIG. 14.—FRONTAL FLAP.

1, Superior frontal convolution; 2 and 3, middle frontal convolution; 4, inferior frontal convolution; 5, anterior limb of the Sylvian fissure; 6, precentral fissure; 7, ascending frontal convolution; 8, fissure of Rolando; 9, ascending parietal convolution; 10, fissure of Sylvius (the first temporosphenoidal convolution is just below this fissure); 11, dural flap.

The second incision passes from the commencement of the first, parallel to the interfrontal and sagittal sutures and about a finger's breadth from the median line, as far posteriorly as the precentral or Rolandic line, according to the extent of the localizing symptoms. The third incision passes from the termination of the second downward toward the external auditory meatus, ending just above the lobe of the ear. The frontal sinus is avoided by making the incision nearer the glabella than the superciliary ridge. Sometimes the bony wall of the sinus is opened, but its mucoperiosteal lining remains intact. If, by any chance, it is opened, it may be packed and drained by cutting away part of its anterior wall.

The flap made in this manner has the advantage of having an excellent blood supply, breaks and turns down easily, gives a good exposure, and is readily converted into a double frontal flap.

The *dural flap* is made of similar shape with its base at the side of the best blood supply—namely, in the temporal fossa. If the frontal sinus has been opened, the dural flap may have its base on that side.

The internal or mesial surface of the frontal lobes may be examined by gentle retraction outward. By raising the frontal lobe its interior surface is brought into view.

EXPOSURE OF BOTH FRONTAL LOBES BY A DOUBLE FLAP (Fig. 15).—Both frontal lobes must be exposed in most tumors situated near the optic chiasm, the beak of the corpus callosum, and the mesial surface of the frontal lobes. Although tumors of the hypophysis may be exposed in other ways, this method gives a freer exposure and a better operative field without undue pressure on the brain from the retractors, so that the operator is able to deal with a more serious and extensive condition and better able to control the hemorrhage and complete the dissection than would be the case through a smaller opening.

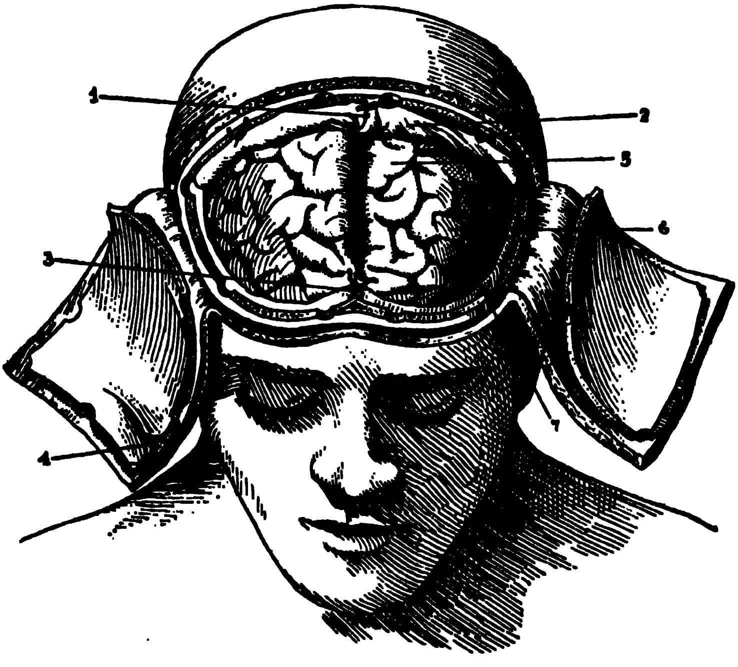

Fig. 15.—Double Frontal Flap.

1, Superior longitudinal sinus; 2, dural flap rolled up; 3, superior longitudinal sinus, its anterior end tied and cut; 4, frontal crest; 5, superior frontal convolution; 6, middle frontal convolution; 7, inferior frontal convolution.

The converting of the single flap into a double one requires but little additional time, hemorrhage or shock, as the mesial cut is common to both flaps. Only the two lateral cuts, one across the forehead and the other down over the precentral or Rolandic line, as described above, have to be made.

The smaller of the two flaps, the one which does not extend across the median line, is broken and turned down first. The dura, with the longitudinal sinus, is separated from the under surface of the other flap before it is broken and turned down.

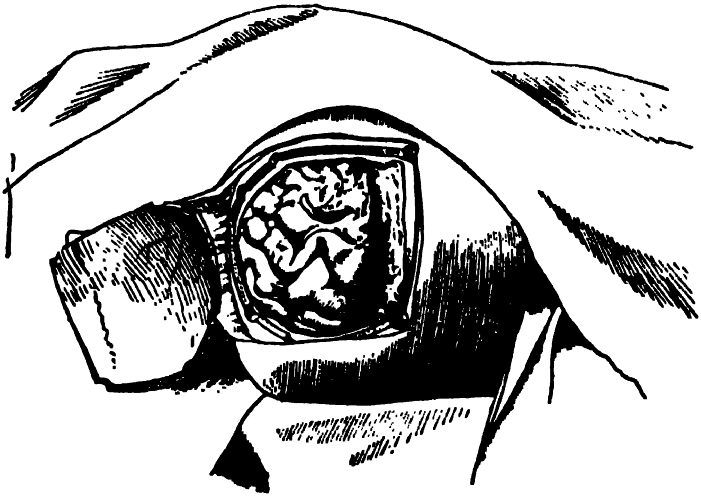

FIG. 16.—SINGLE FLAP ON VERTEX, EXPOSING LONGITUDINAL SINUS AND MESIAL SURFACE OF HEMISPHERE.

The *dura* is cut according to the condition found. If the lesion is apparently limited to one side, the dura is cut with its base along the longitudinal sinus toward which it is retracted.

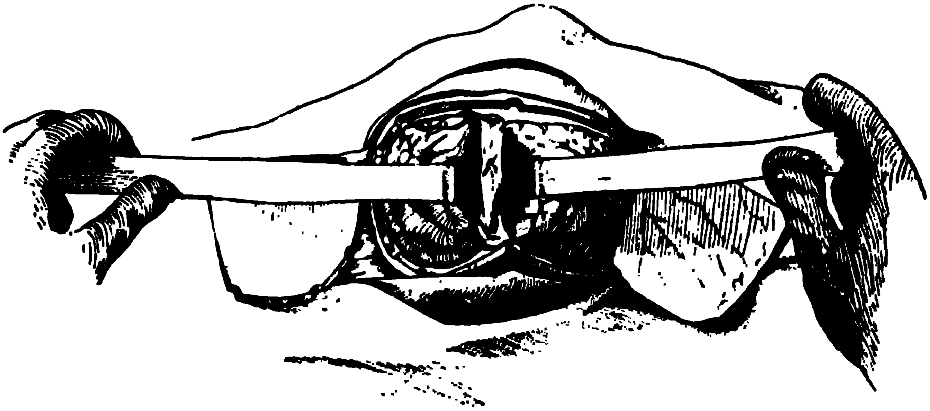

FIG. 17.—DOUBLE FLAP ON VERTEX. Both cerebral lobes retracted exposing conditions along the mesial surface and the falx cerebri down to the corpus callosum.

If both frontal lobes, either their mesial surfaces or their inferior surfaces, or lesions in the vicinity of the optic chiasm or hypophysis are to be rendered accessible, the longitudinal sinus is cut between double ligatures close to its attachment to the ethmoid bone and the falx cerebri divided. The incision in the dura is then carried laterally, following the margin of the bone incision. This gives a dural flap with a long base situated above and posteriorly. With broad flat retractors, the frontal lobes are readily lifted upward and outward.

Many lesions in this region have not been satisfactorily dealt with, partly, no doubt, because of insufficient exposure.

Exposure of Lateral Aspect (Figs. 18, 19).—This includes the whole sensorimotor area, and on the left side in right-handed people, the speech centers. In order that the flaps may not be too large, this area is divided into an anterior and a posterior half — the anterior for cases in which the motor symptoms predominate and the posterior for those cases in which sensory symptoms predominate.

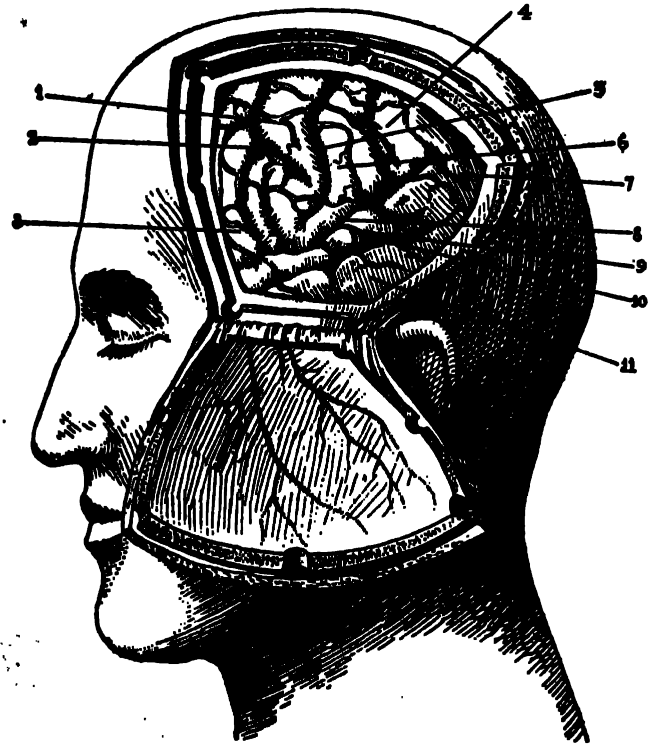

FIG. 18.—ANTEROLATERAL FLAP.

1, Ascending frontal convolution; 2, precentral sulcus; 3, ascending arm of the Sylvian fissure; 4, inferior parietal convolution; 5, fissure of Rolando; 6, ascending parietal convolution; 7, supramarginal convolution; 8, fissure of Sylvius; 9, superior temporosphenoidal convolution; 10, first temporosphenoidal sulcus.

ANTEROLATERAL ASPECT (Fig. 18).—The flap for the anterior part of the lateral aspect is bounded anteriorly by a vertical line, 1 finger's breadth in front of the precentral line, and posteriorly by a line beginning near the posterior end of the Sylvian line and extending downward and forward to just above the lobe of the ear.

The upper ends of these 2 incisions are joined by another, 1 to 1.5 cm. from the median line and parallel to it. The base is in the squamous portion of the temporal bone. Along the upper or mesial edge several extra holes may be required to detect differences in thickness due to Pacchionian bodies.

Also along the anterior edge at the temporal ridge extra holes will be required, as here the bone may vary in thickness from 1 to 10 mm. and one must know whether to change the washer, to cut on a bevel or to cut straight.

The *dural flap* is made of much the same shape but preferably with its base a trifle more anteriorly, particularly when working on the left side, as this permits a good protecting dural flap, free from sutures, to rest over the important cortical centers and protect them from injury and adhesions.

The middle meningeal artery never gives one any anxiety, as it is easily controlled by passing under and around it a fine curved needle with a catgut ligature. If the vessel is located in a tunnel or foramen in the bone and starts bleeding, bone wax or a sharpened stick crowded into the opening will stop it. The same procedure will control the bleeding at its entrance into the skull through the foramen spinosum.

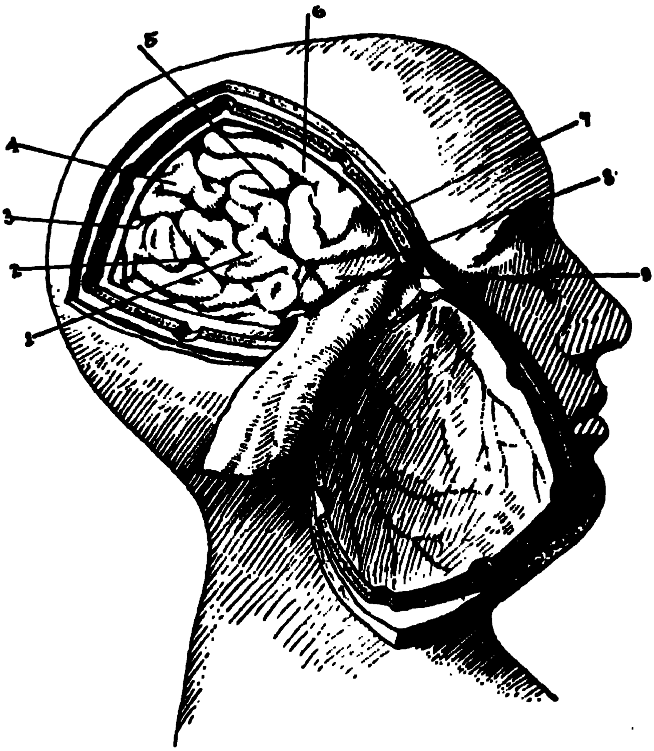

FIG. 19.—POSTEROLATERAL OR PARIETAL FLAP.

1, Supramarginal convolution; 2, angular convolution; 3, external parieto-occipital fissure; 4, superior parietal convolution; 5, inferior parietal convolution; 6, ascending parietal convolution; 7, fissure of Rolando; 8, fissure of Sylvius; 9, first temporosphenoidal convolution.

The *flap for exposing the Gasserian ganglion* is of this character (Fig. 18), only much smaller, say 3 to 4 cm. at its base, placed as low in the temporal fossa as possible. Its upper edge, 4 to 6 cm. long, is parallel to the median line and about ⅓ to ½ of the distance to the median line, its sides, 4 to 6 cm. long, diverging upward. The anterior side should be at least a finger's breath behind the external angular process in order to avoid the branch of the facial nerve.

POSTEROLATERAL ASPECT (Fig. 19).—This flap exposes the ascending parietal convolution, the superior and inferior parietal, the outer portion of the cuneus, the supramarginal and angular gyrus and the first and second temporosphenoidal convolutions.

It is indicated in those cases commencing with disturbances of sensibility, followed by some disturbance in motion of the extremities with a gradual hemianopsia and loss of language, or for those cases of sensorial aphasia commencing with hemianopsia.

Anteriorly the flap starts from the junction of the precentral line and the Sylvian line. This anterior border of the flap extends obliquely upward and backward to terminate just behind the Rolandic line, about a finger's breadth from the sagittal suture. The lower, or posterior, border follows fairly closely the 80 per cent. line, dipping somewhat below it anteriorly to terminate just above the lobe of the ear. The upper border is parallel to the median line and about 1 cm. from it. The base is in the posterior part of the temporal fossa.

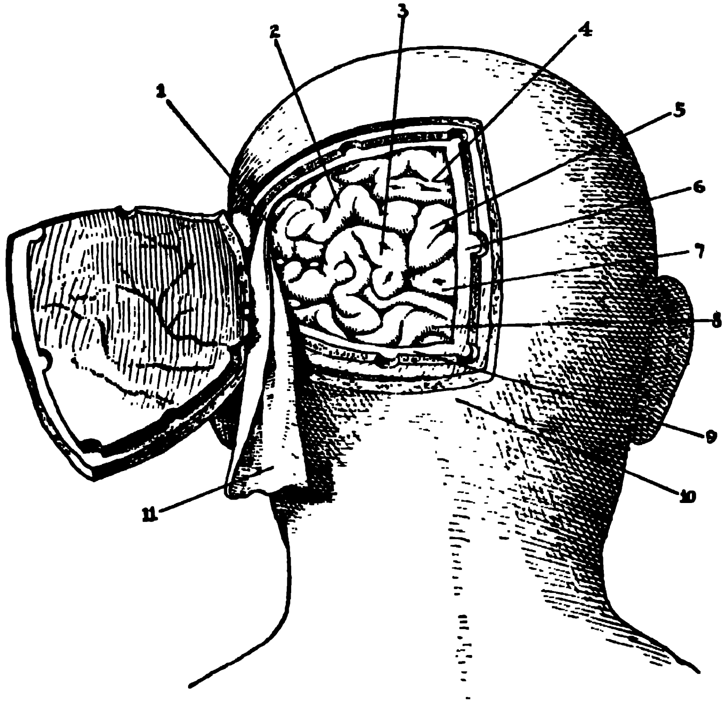

FIG. 20.—SINGLE OCCIPITAL FLAP.

1, Superior occipital convolution; 2, dural flaps rolled up over the longitudinal sinus; 3, second occipital convolution; 4, third occipital convolution; 5, reflected bone flap.

The *dural flap* is made of the same shape as the bone flap, only somewhat smaller—about 0.5 cm. on each side to facilitate subsequent suture.

Exposure of Occipital Region (Fig. 20).—The lower border of the flap commences above the external auditory meatus near the posterior root of the zygoma, passes backward, about 1 cm. above and parallel to the 95 per cent. or lateral sinus line, to within 1 cm. of the median line. From here the posterior border extends upward parallel to the median line to a point about 1 cm. above the Sylvian line. The upper border of the flap extends from this point downward and forward nearly parallel to the Sylvian line and terminates above the external auditory meatus, or about opposite the fourth tenth on the Sylvian line.

This gives a flap with a base nearly vertical above the ear and between 4 to 6 cm. (1 3/5 to 2 2/5 in.) wide.

The *dural flap* is made in a similar manner.

EXPOSURE OF BOTH OCCIPITAL LOBES BY A DOUBLE FLAP (Fig. 21).—When it is necessary to expose both occipital lobes, 2 flaps are made, similar to the above-mentioned one. One is completed, the dura opened, and the condition inspected. Then the dura, bone and soft parts are returned to their proper positions in order to protect the brain. Another flap is then made, similar in shape, though perhaps smaller, with its mesial edge in common with the first. In this case of a double exposure, the *dural flaps* may correspond to the osteoplastic flaps or they may be cut in the reverse direction and rolled up along the longitudinal sinus, which obviates any bleeding from vessels entering the sinus.

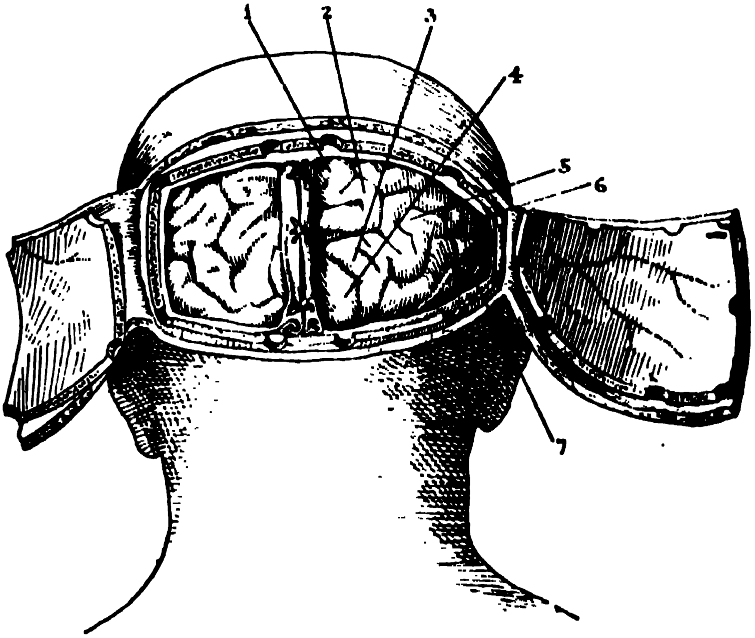

FIG. 21.—DOUBLE OCCIPITAL FLAP.

1, External parieto-occipital fissure; 2, first occipital convolution; 3, second occipital convolution; 4, third occipital convolution; 5, angular convolution; 6, supramarginal convolution; 7, first temporo-sphenoidal convolution.

EXPOSURE OF BOTH OCCIPITAL LOBES BY A SINGLE FLAP (Fig. 22).—This does not give the good exposure of the double flaps, but is somewhat simpler of execution, with less drilling and sawing.

The lateral incisions for this single occipital flap exposing both sides pass upward and outward from the junction of the middle and outer thirds of the superior curved line of the occipital bone to the Sylvian line and then follow this line posteriorly to meet in the median line at the 70 per cent. point.

Drill holes are placed on either side of and also over the longitudinal sinus. Drill holes are also made at the corners and along the sides wherever the bone varies more than 2 mm. in thickness. The lower and external corners should have 2 or 3 additional holes made toward the median line.

The scalp over the middle point of the base of the flap, that portion which is just above the external occipital protuberance, should be incised in the mid line for 3 to 6 cm. (1 1/5 to 2 2/5 in.), retracted from the bone laterally, and 3 to 4 drill holes made in the bone, thus narrowing the part to be broken. The bone in this region is thick, perhaps 5 to 10 mm. (1/5 to 2/5 inch), and unless it is weakened by drilling the holes, or with the slot-cutting forceps, the line of breakage may not occur where desired. In this method of exposing both occipital lobes by a single osteoplastic flap, 2 *dural flaps* (Fig. 21) are made with their bases toward the longitudinal sinus.

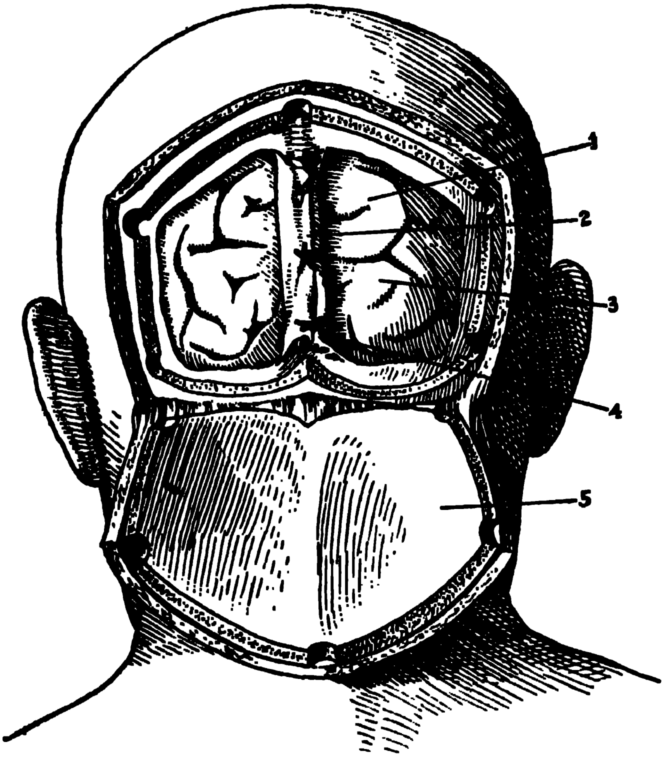

FIG. 22.—SINGLE OCCIPITAL FLAP EXPOSING BOTH HEMISPHERES.

1, First occipital convolution; 2, dural flap rolled toward median line, over the longitudinal sinus; 3, second occipital convolution; 4, third occipital convolution; 5, reflected bone flap.

Flaps for Exposing External Boundaries of the Outer Wall of the Cerebellar Fossa and the Cerebellar Pontine Angle (Fig. 23).—In exposures of the outer surface of the cerebellar fossa, the lateral sinus, the posterior surface of the petrous portion of the temporal bone and the internal auditory meatus, where a large opening is not required, the following flap is made.

Dr. Alfred S. Taylor has employed this flap for exposing and dividing the pars intermedia of Wrisberg at the internal auditory meatus.

The upper border of the flap extends from a point near the median line about 2 to 3 cm. (4/5 to 1 1/5 in.) above the superior curved line forward and outward to a point over the posterior border of the mastoid. The external border of the flap extends from the outer end of the upper boundary downward and inward over the posterior edge of the mastoid process to a point just above the foramen magnum. The mesial border of the flap extends from the inner end of the upper incision downward about 0.5 cm. from the median line to a point just above the foramen magnum.

The scalp along these lines is cut down to the bone, the hemorrhage being controlled by a Heidenhain stitch or by a suture of the cut edge, or by a clamp and suture.

The soft parts, with the periosteum, are separated from the bone for a distance of about 1 cm. with a periosteal elevator and over what will be the fractured edge a complete separation is made. Holes are drilled at the corners and along the sides. Over the region of the lateral sinus 3 holes are made close together, 1 on either side and 1 directly over it, in order to furnish an accurate measurement of the thickness of bone covering it. The region of the mastoid may require several holes.

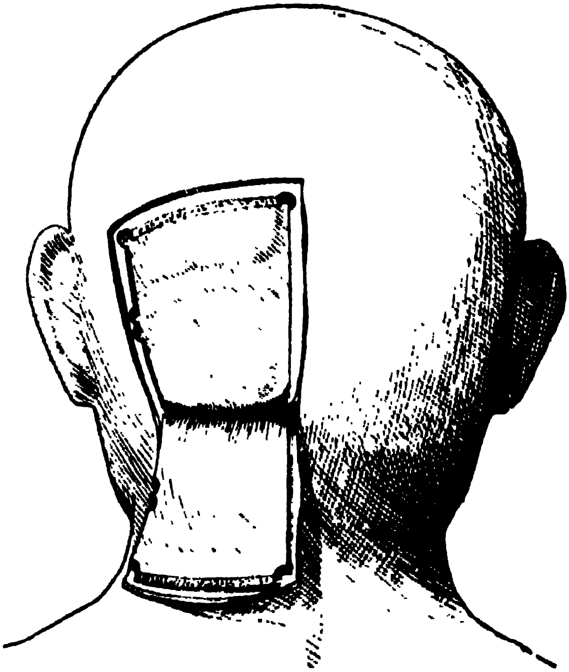

Fig. 23.—Flap for Exposing Cerebellar Pontine Angle, One Side.

The base of the flap should be narrowed and weakened as much as possible by drilling several holes under the retracted soft parts, or the same result may be obtained with the slot-cutting forceps, working from the retracted lower end of each lateral incision toward the middle of the base. The thickness of the bone at the various holes is measured. A suitable guard is selected and placed on the circular saw and the bone cut.

The uncut portion of bone, perhaps 1 to 2 mm., is cracked by inserting a thin osteotome in the saw cut and striking it with a mallet. The bone flap is turned down toward the neck, its fractured edge being just above the foramen magnum. This narrow margin of the foramen may be cut out with the rongeur forceps if there is any danger of the medulla being jammed down into it.

The *dural flap* may be turned down in a similar direction, or it may be made with its base toward the median line. Bleeding may be controlled by pressure, clamp, ligature, or a fine suture of catgut or silk.

The cerebellum is retracted toward the median line by a broad flat brain retractor. A clear field is obtained by removing the blood and cerebrospinal fluid by a small tube of soft metal bent at an appropriate angle and connected with a continuous suction apparatus. In addition to this, small gauze sponges about 1 cm. in diameter are used. Good illumination at the bottom of this rather deep and narrow wound is essential and may be obtained by a head light or head mirror worn by the operator, or, better still, by using a small electric light, similar to that used in a cystoscope, mounted on a long flexible holder and held by the assistant in the corner of the wound which is most convenient for the operator. This wire, holder and lamp can all be sterilized.

This method has the advantage of furnishing the light very near the structures to be dealt with and between them and the operator's hands, thus eliminating nearly all of the shadows.

If this exposure should reveal a more extensive condition than was anticipated when the bone flap was planned, as, for instance, a tumor requiring removal of bone over both cerebellar lobes, another flap, similar to this one but somewhat larger, taking in the remaining bone on the other side, may be fashioned in the same manner. These two flaps, when retracted downward and outward, with a rongeur removal of the posterior margin of the foramen magnum, will give the maximum exposure.

The dural flap may be made with its base along the lateral sinus. The occipital sinus is divided between double ligatures low down in the cerebellar fossa. The cerebellar falx is divided and a curved incision, with its convexity downward, is made to extend outward and upward over each cerebellar lobe almost to the outer end of the lateral sinus. The division of the cerebellar sinus and falx is quite necessary to give the desired mobility, so that free retraction of the cerebellum may be made without undue pressure.

If a decompression is desired, the entire bone may be removed and only the soft parts returned and sutured.

Single Flap Exposing Both Occipital Lobes of the Cerebrum and Both Cerebellar Lobes (Similar to That Employed by Duret and Krause) (Fig. 24).—This method of making osteoplastic flaps is attended with little, if any, increased risk to the patient or trouble for the surgeon, even if the size of the bone flap is considerably greater than usual. Large flaps are cut almost as easily and as quickly as small ones. The subsequent return of the bone and the primary union give a protecting cranium as serviceable as before the operation. The free exposure furnishes the best chance of a thorough inspection and a safe and satisfactory treatment of the condition found.

The bone may be safely divided over any of the sinuses without danger of injuring them. Bone flaps extending over venous sinuses are easily turned down without damage to the dura or sinus wall. The few emissary veins which are torn across rarely give troublesome bleeding and are easily controlled by slight pressure or a very fine suture.

Bearing these points in mind, the exposure to be described will be indicated in numerous conditions and may be safely and quickly made.

POSITION OF PATIENT. The patient is first anesthetized in the regular way, then a change is made to the nasal anesthesia (see page 750). When this is working satisfactorily the patient is turned flat on his face with a large sand bag under each shoulder to relieve the chest of the body weight and facilitate breathing. The forehead rests on a support which is adjustable, up or down, in or out. For a detailed description of position of patient see page 749.

TECHNIC.—The method of making this flap is as follows: The upper border of this large single flap exposing the entire occipital region corresponds to the 80 per cent. point in the median line and extends laterally on each side along the temporosphenoidal line of Chipault's topography, to a point over the posterior border of the mastoid process. The lateral incisions extend from the outer ends of this superior cut downward and inward, skirting the posterior border of the mastoid process and reaching well down on the neck. A short incision, 4 to 6 cm. (1 3/5 to 2 2/5 in.) long is made in the midline over the external occipital crest from below the occipital protuberance down to within 1 cm. of the foramen magnum.

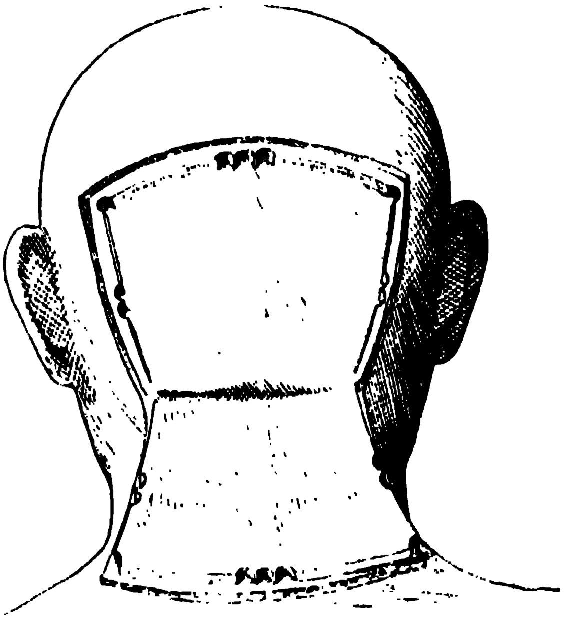

FIG. 24. SINGLE FLAP FOR EXPOSING BOTH OCCIPITAL LOBES OF CEREBRUM AND BOTH LOBES OF CEREBELLUM.

The hemorrhage from the scalp is best controlled by a double row of Heidenhain sutures. Bleeding from the mastoid foramen is controlled by bone wax or a wooden plug.

The soft parts are separated from the bone with the periosteal elevator for a space of 1 to 2 cm. in width, following this cut which has been made down to the bone. Over that portion of the flap which is to be the fractured edge, the soft parts are completely lifted from the bone, utilizing the median incision for the purpose.

Drill holes are made at the corners, along the sides, 3 close together over each sinus, and several others at short intervals along the base of the flap, particularly over and on either side of the occipital crest. The entire width of the bone at the base of the cerebellar fossa, about 1 cm. from the posterior margin of the foramen magnum, may be weakened by numerous drill holes, placed close together, in order to insure its accurate breaking. While doing this, the soft parts should be well retracted, utilizing the middle incision as well as the two lateral ones. The sawing, cracking, and turning down of the flap are similar to that described for other regions.

While turning down any bone flap, strong outward traction should be made on it so that the fractured edge will not dig into and injure the brain.

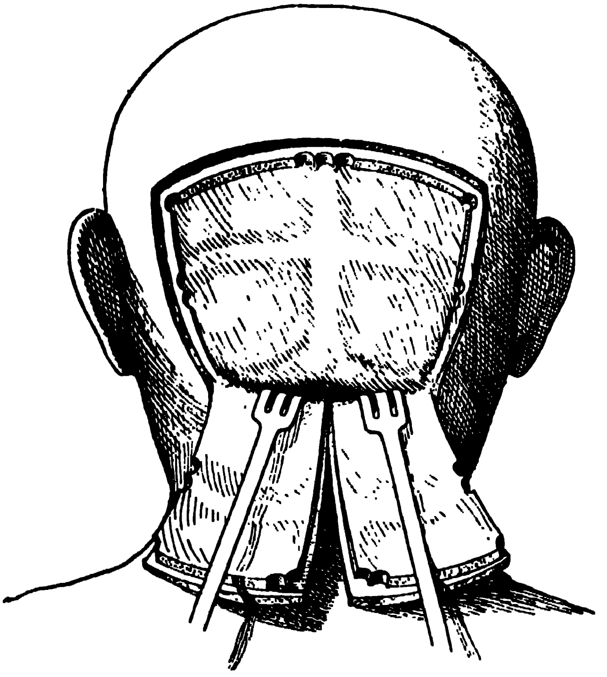

FIG. 25.—SAME FLAP AS SHOWN IN FIG. 24, SPLIT DOWN MIDDLE AND RETRACTED DOWNWARD AND OUTWARD TO GIVE A BETTER EXPOSURE.

As soon as the flap is turned down all the hemorrhage should be quickly and carefully controlled. Then the flap is wrapped in a gauze pad wet with hot salt solution.

In many cases the next step will be the removal of the posterior margin of the foramen magnum with the rongeur forceps.

If the patient has a short thick muscular neck, difficulty may be experienced in retracting this flap downward far enough to give a good working exposure of the cerebellum. In these cases, while the bone is pulled down as much as possible and a broad flat metal brain retractor is held over the brain to protect it, the circular saw, with or without a guarding washer, is made to cut the bone down the midline from within outward (Fig. 25). Even if the saw cuts all the way through the bone no harm is done, as later the soft parts are divided in the same line with a scalpel.

This procedure gives two equilateral osteoplastic flaps which may be retracted downward and outward affording a very generous exposure, which is quickly and easily made regardless of the bone thickness or density, yet with such an accurate fit and such good blood supply that a primary union follows with a normal bone protection for the important intracranial structures at this point.

This large flap, exposing both occipital lobes of the cerebrum and both cerebellar lobes, with a dural opening and a rubber tissue drain in each compartment, has been successfully employed to provide drainage in cases of meningitis.

Exposure of the Gasserian Ganglion.—The exposure of the Gasserian ganglion, either for its removal or for the division of its sensory root, may be made by any one of several different methods, namely that of Poirier, Rose, Cushing, or the Hartley-Krause method.

The late Dr. Frank Hartley and Dr. Fedor Krause devised, almost simultaneously, a method of approaching the Gasserian ganglion through the middle fossa of the skull above the zygoma.

The incision, as originally devised, was that of an inverted horseshoe or omega with the base about 5 to 6 cm. (2⅖ in.) and 5 cm. (2 in.) at its widest part. The anterior incision should be about a finger's breadth behind the external angular process in order to avoid the branch of the facial nerve to the eyelid muscles. The posterior incision begins just in front of the ear and extends upward and backward. The skin incision was subsequently changed to a trapezoidal shape, of approximately the size and shape described above. This is similar to the exposure shown in Figure 18, only the flap is much smaller in size. The hemorrhage from the scalp is controlled by one of the methods already mentioned, preferably by the Heidenhain suture.

The incisions are made down to the bone at one stroke of the scalpel. The soft parts are separated a short distance on either side of the incision, using the periosteal elevator. The anterior border is retracted well forward, carrying the nerve with it. Drill holes are now made at the corners, along the sides, and with 1 over and 1 on either side of the greater wing of the sphenoid and 1 at the bottom of both the anterior and posterior incisions.

The thickness of the bone is measured at each hole, and these numbers are jotted down on a rough sketch for reference when adjusting the saw. The circular saw, protected with a suitable washer so that 1 or 2 mm. of bone will remain uncut, is made to cut from one hole to another. If the bone thickness varies more than 2 mm. between holes, another hole should be made between them. All portions which are of fairly uniform thickness may be cut without changing the washer. Varying the angle of the saw to the skull surface from 90° to 45° will diminish the depth of the cut from 1 to 2 mm. This may be done or the washer may be changed. It is rather better to cut the thicker portions of the flap first, leaving the thinner part, particularly the lower anterior portion, until the last, as more hemorrhage is apt to occur from this side. Bone wax in the holes and saw cut will control the bleeding.

A thin osteotome is inserted in the saw cut at the different holes and lightly tapped with a mallet. The osteotome should be held nearly parallel to the skull surface and should be systematically applied at each hole. A few extra taps will be required at the holes where the uncut portion is known to be thickest.

When the flap is cracked all along the saw cut it may be pried up gently until some strong instrument, as a curved periosteal elevator or osteotome, can be inserted under it. A quick downward pry with this elevator under the upper edge of the flap and a firm pressure with the thumb just above the zygoma break the bone low down in the temporal fossa.

Strong firm outward traction is made on the flap as it is being turned down so that the ragged fractured edge will not damage the dura. If this edge is very uneven, it should be trimmed off with the rongeur forceps.

Bleeding from the bone is controlled by wax or by crushing the bleeding point. The flap is wrapped in a hot wet towel or gauze pad. A sharp retractor with rather large teeth is gently placed low on the muscle forming the hinge, so that the pull down toward the cheek all comes on the muscle and none on the bone flap, which is easily torn off if not carefully protected.

The opening is now enlarged downward underneath the zygoma until the floor of the middle fossa is reached. The narrow part of the opening may be enlarged both anteriorly and posteriorly with the rongeurs if required.

The finger, aided by the broad flat brain retractor, quickly separates the dura from the floor of the temporal fossa until the foramen rotundum and the foramen ovale are seen. Some bleeding may result from this dural separation, but it is easily controlled, either by placing a gauze pad on the dura and making pressure over it with the brain retractor, or by putting in gauze pads or packing and making firm pressure with the hand and waiting a few moments. A distinct bleeding point in the bone may be controlled with bone wax. Vessels on the surface of the dura which are torn may be clamped and tied, or, better still, surrounded with a fine catgut or silk suture on a fine curved needle and ligated.

It seems wise to give a rather full account of this technic because of the peculiar conditions met with, and because the success of this operation, perhaps more than any other, depends so much upon the preliminary planning for the various steps and the attention to detail.

The operator should stand at the end of the table, holding the brain retractor with his left hand, while, with his right hand, he presses back the dura, using one of several long narrow dural separators, which are slightly curved at the tip, for the purpose. Only the few instruments required during this stage of the operation—such as 2 or 3 brain retractors, separators, long thumb forceps, long slender scalpel, and blunt tenaculum—and no others, should be placed on a tray very close to the operative field.

It is most necessary to obtain a clear view of the structures at the bottom of the wound and, to accomplish this, rapid, accurate and effective sponging is essential. For this purpose there should be available a generous supply of gauze rolled up into firm little balls of 2 or 3 sizes, some 1 cm. in diameter, others 2 cm. and a third size about 3 cm. in diameter. These sponges should be kept in 3 distinct piles very close to the wound, within 4 inches, so that they may be picked up readily and quickly with long thumb forceps, by the assistant or by the operator without loss of time and without the necessity of turning the eyes from the operative field. A few drops of blood or cerebrospinal fluid will conceal everything, and it is necessary that this be quickly removed and the gentle but rapid dissection be attempted during the few moments when the field is clear and before the reaccumulation of the fluid. Continuous suction is most useful during this operation and should be used in addition to the sponging. It is applied through a soft metal tube 5 mm. (1/5 in.) in diameter, and 10 to 15 cm. (4 to 6 in.) long, bent to a suitable curve. This tube is held out of the way down in one corner of the wound by the assistant, and, as occasion requires, is lightly and quickly swept over the line of dissection.

Good illumination is very necessary, to obtain which a drop light, a head mirror, or head light may be used. The objection to having the source of light attached to the operator's head is that, whenever he turns for any reason, the depth of the wound is thrown into shadow and the assistant is unable to perform his part effectively until the light returns.

A very efficient method of illumination is the employment of a small electric light similar to that used in a cystoscope. This is attached to a soft metal tube which can be bent as required.

The lamp holder and wire are sterilized by boiling for a few minutes, or they may be sterilized by placing them in a solution of carbolic acid or formaldehyd. This lamp is held down in one corner of the wound by an assistant, is moved about as occasion requires, and furnishes a good steady light near the working end of the instruments so that there are no annoying shadows. The hemorrhage at times is rather profuse, but the introduction of 1 or 2 of the larger sponges and the application of pressure for a few moments will generally control it.

When the bleeding point or area can be detected, a very small gauze pad 0.5 to 1 cm. (1/5 to 2/5 in.) in diameter may be placed directly over it and then firm, gentle pressure made over this pad with a uterine sound bent at a right angle. For the same purpose, and to be used in much the same way, we have devised a malleable rod similar to a uterine probe with a soft rubber tip about 0.5 cm. in diameter. Gauze pads soaked in adrenalin and packed in the wound for a few minutes often control the bleeding.

Manipulation of the brain retractor, with or without a gauze pad under it, so that the pressure is made over the bleeding point is a very effective way of controlling the hemorrhage from the dural side and from the depth of the wound.

The second division at the foramen rotundum is exposed, then the third division at the foramen ovale. The dural reflexion along the outer border of the ganglion is split close to the ganglion and, with the separator, is pushed from its upper surface toward the median line. The dissection is also carried posteriorly in the same manner until the outer edge of the root is seen.

The middle meningeal artery as it enters the skull at the foramen spinosum may be torn or intentionally divided. The bleeding is easily controlled with gauze pad and pressure, with wax, wire clips, or a ligature on a small curved needle.

When the dissection is fairly complete, so that the contour of the ganglion with its second and third branches can be made out, a short, curved, blunt tenaculum is passed under the second branch to lift it slightly and pull it from the foramen into the skull. A long narrow tenotomy knife is used to cut the nerve as low down in the foramen as possible. The cut is made directly against the bone. The third branch is divided in the same way. The first or ophthalmic division is not seen and probably remains intact until the root is divided, when most of its fibers are cut or torn across.

A long slender clamp or thumb forceps is now used to lift the ganglion from its bed and to facilitate its further separation, which is continued posteriorly until its greatest width is passed and the tapering down to the narrow root is seen. At this point the final division is made outward and backward.

Gauze packing for a few moments and the return of the brain to its normal position will control most of the oozing. Some cases may require a small cigarette drain carried along the floor of the middle fossa and brought out of the lower angle of the wound. This may be removed after 24 to 48 hours.

The osteoplastic flap is returned to its place and carefully sutured. Several interrupted sutures of plain or chromated catgut are placed in the muscle and fascia, and a continuous suture of fine silk in the skin. A generous gauze dressing and firm even pressure with a gauze bandage, a few turns of which are placed under the chin, are applied. Sometimes a starched bandage is used over the gauze one. Instead of two layers of sutures, interrupted silk sutures through all the soft parts down to the bone may be used.

Instead of removing the ganglion the same result may be accomplished by dividing its sensory root. The procedure is identical with that described above, except the dissection of the second and third branches, which are merely located but not exposed.

A short incision is made in the dura parallel to the anterior surface of the petrous portion of the temporal bone, posterior to the middle meningeal artery near the foramen spinosum. Retraction of this incision reveals the sensory root, which may be lifted with a blunt tenaculum and divided.

A suture may be used to close this small cut in the dura, though this is not necessary. **The wound is closed as mentioned above. No drainage or permanent packing is used unless absolutely necessary.**

FILLING IN A BONE DEFECT IN THE SKULL

Various methods have been employed to restore the protecting skull, when, for any reason, a portion of it has been lost.

Bone from the same person, or from some other person, or some foreign material, as aluminum, silver, celluloid, or celloidin, have been used.

Bone Transplantation.—The outer table of the bone adjacent to the opening may be split from the inner table and, still attached to the overlying soft parts, swung over to cover the defect, while the area of the inner table left bare by this procedure is covered with a graft. This method is of limited application and difficult of execution.

PORTION OF RIB OR TIBIA FROM THE SAME PERSON.—After the preliminary preparation as described for any head operation, a scalp flap about 1 to 2 cm. (2/5 to 4/5 in.) larger on every side than the opening in the skull is turned down. A careful separation is made at the area where the scalp is adherent to the dura. If the dura is thick and adherent to the cortex, perhaps giving cortical symptoms, it may have to be dissected free. The bleeding is controlled by gentle pressure, fine sutures or bits of muscle.

The bony edge of the opening is carefully freshened by using the rongeur forceps, or, better still, by drilling several holes about 1 cm. (2/5 in.) away from the edge, measuring the skull thickness and cutting off a thin strip of the bone with the circular saw protected by the proper guard. A thin piece of metal may be slipped across the opening and under the bone to furnish an additional protection. These saw cuts should be made at an extreme bevel. The opening is accurately measured from side to side and from above downward, and the amount of bone required is estimated.

One or two ribs are exposed for a distance sufficient to furnish the amount of bone desired. The ideal method would be to leave the periosteum undisturbed on both sides of the rib, but on account of the danger of injuring the pleura, it is usually stripped from the bone on the inner surface as in an ordinary rib resection.

In order to make the rib cover more area in the skull it may be split with the circular saw from edge to edge, thus furnishing two thin strips which will cover just twice as much surface. The ends are cut at a bevel which will accurately fit the bevel at the sides of the opening, so that the piece of rib will rest on the skull and cannot be driven down upon the dura.

One or two drill holes made at each end of the piece and corresponding holes made in the skull will permit a few chromated catgut sutures to be inserted to hold the bone in place. Several of these pieces placed side by side in a direction to utilize to the best advantage the curvature of the rib may be required to fill the defect. Just before the bone is put into place, it may be advisable in certain cases where the dura is lacking to place a thin sheet of celloidin, as recommended by Dr. Prime, over the surface of the brain to prevent adhesions. This seems to be better than Cargile membrane, which has been used in the same manner.

The scalp is now returned and carefully sutured into place.

Instead of a rib, a piece of bone with its periosteum intact on one edge and a side may be cut from the tibia with the circular saw. This piece of bone may be cut very thin throughout the central 2/3 so that it may be bent and sprung into place.

The ends may be notched to engage on the margin of the opening, or the outer table all around the opening may be cut away 5 mm. more than the inner table, thus leaving a shoulder or shelf into which the ends of the thin strips of bone may be sprung.

Instead of making the bone graft very thin, several saw cuts 5 to 10 mm. apart can be made at right angles to the long axis nearly through the entire thickness of the bone on what will be the inner or concave side. This will permit of the piece being easily bent. But an accurate fit with the proper curvature is rather difficult. This is true of the transplanting of any bone to fit the curvature of the skull.

Foreign Materials.—Of foreign materials we have used aluminum and celluloid. Both have healed satisfactorily and given no subsequent trouble, but the celluloid is so much easier to fit that it is to be given the preference.

CELLULOID.—After the preparations already described, the scalp flap is turned down, the bony edge of the opening cut off with the circular saw, and the dura and brain prepared as the condition demands.

A piece of ordinary commercial celluloid, 2 to 3 mm. thick, translucent rather than opaque—as this enables one to make the tracing through it—is sterilized by boiling and while hot is given a curve similar to that of the skull at the site of the operation.

This celluloid is laid over the opening in the skull and, being translucent, a careful tracing can be made on it with a needle, scalpel, or some sharp-pointed instrument. The tracing should follow the opening in the outer table, which, because of the beveled saw cut, is slightly larger than that in the inner table.

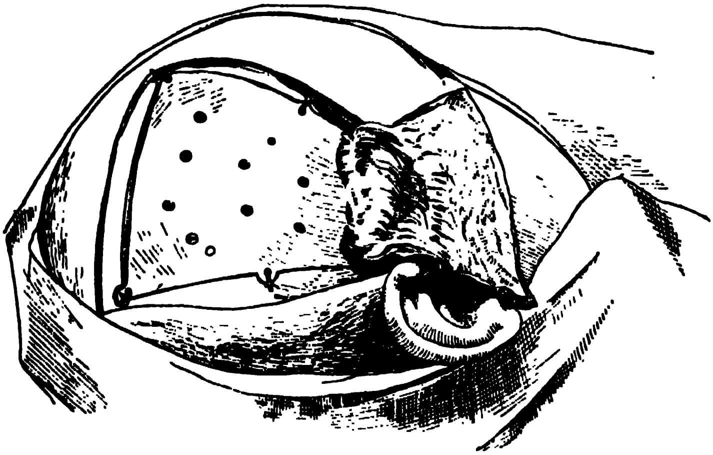

FIG. 26.—METHOD OF FILLING A BONE DEFECT IN SKULL WITH A CELLULOID PLATE. The plate is moulded to the proper curvature while warm, and drilled at the corners and sides and sutured to corresponding holes in the skull with chromated gut. The scalp is firmly sutured in place over this plate.

A fine scroll saw in a hand frame is used to cut the celluloid along the tracings. This cut should also be beveled so as to fit the skull opening better. It is well to leave slight projecting tips on the celluloid which will fit into the burr holes made in preparation for the saw cuts around the skull opening.

If the celluloid has not been curved enough when the tracing is made on it, the saw cut should be made a trifle larger than the tracings. The piece of celluloid is now tried over the opening, and marked again where additional trimming may be required. The amount and direction of curvature it should have are also noted. With a long sponge clamp the celluloid is held for a few minutes in the boiling water of the sterilizer, then removed and, while still hot, is quickly bent to the proper curvature with the thumbs and fingers. It is then held in this position until immersed in cold sterile water which hardens it. It is now tried again over the opening and perhaps one side or one corner will not fit accurately and will require a different curve. To obtain this only the necessary portion of the plate is put into the boiling water, and the desired part is bent with a strong clamp. This trimming, trying, heating, and bending may seem to be a rather tedious process, but really takes very little time. The plate should rest against the beveled edge of the opening, its upper surface even with the surface of the skull and with a similar convexity.

When these conditions are obtained, the celluloid plate is very firmly fixed, cannot be slid in any direction, and cannot be pressed in, as the principle of the supporting arch is present. To prevent the displacement of the plate during the subsequent suture of the flap, small drill holes about 1 to 2 mm. in diameter are made obliquely in the bone near the edge of the opening, at the corners, and also one on each side. A thin flat piece of metal is held between the dura and the bone at the point of drilling to protect the brain. The plate is held in its proper place and a little mark made on it opposite each hole in the bone, and the plate is then removed and drilled. Several holes may be drilled around the central part of the plate, as shown in Figure 26, to allow any collection of fluid or serum to escape.

Fine chromated sutures are passed through all the holes in the bone and the corresponding ones in the plate, cut long and clamped. The plate is lifted far enough to afford a final inspection of the dura or brain surface and the adjustment of the celloidin or Cargile membrane. It is then replaced and the sutures tied (Fig. 26). The scalp is returned to its proper place and carefully sutured.

In a few cases there has been a collection of serum or cerebrospinal fluid between the scalp and the plate. If this does not disappear with the firm pressure of the dressing, it may be removed with an aspirating needle or allowed to escape through a small incision. This fluid has never given any further trouble.

FRACTURED SKULL

Simple Fracture with Depressed Bone.—Simple fractures with depressed bone, although there are no intracranial symptoms, should be operated upon and the depressed bone raised. The inner table is almost always more extensively damaged than the outer signs would indicate, and the best prevention of future trouble is the immediate repair of the displacement.

In certain cases the depression in the bone is exposed by a linear incision, a small hole drilled part way through the depressed bone and into this hole a threaded hook or a screw eye is turned in order to furnish a means of making outward traction to lift the bone into place.

In other cases the bone is exposed by a linear incision, the periosteum pushed back, the crack enlarged with a narrow gouge or a chisel until some prying instrument can be inserted under the depressed edge and, with another elevator or chisel as a fulcrum on the adjoining bone, the depressed bone is pried into place.

Still another method is to construct a regular osteoplastic flap, as described previously in this article, with the depression as its center. When the impacted and depressed bone is turned down in the flap, pressure with the thumbs, or some instrument, or light blows with a mallet on its inner surface will suffice quickly to restore the normal curvature without loss of bone substance.

The advantage of this method is that a careful inspection for damage of the dura and brain by fragments driven in and also for extra- and intradural hemorrhage can be made and the proper treatment carried out.

Scalp Wounds with Possible Fracture.—Scalp wounds with possible fracture should be enlarged in order to make a correct diagnosis.

If only a clean linear crack is found and there are no complicating symptoms indicating intracranial lesions, the treatment is only that of a scalp wound. But if there is dirt or hair in the fracture, the crack had better be enlarged with the chisel or gouge or holes drilled at each end and along each side, the thickness of the bone measured, and, with the circular saw properly guarded, a narrow strip of bone removed from each side of the fracture. This removes the dirty and possibly infected bone. It gives a view of the dura and an opportunity to detect subdural lesions, which if present, can be properly dealt with. If these pieces of bone bordering on the crack can be thoroughly cleaned and rendered aseptic, and if the dura and brain are not lacerated, they may be returned to their proper place. The wound is closed with rubber tissue drains.

Compound Fractures.—The compound fractures are treated as follows: The bone is exposed, either by enlarging the original wound, pushing back the periosteum and removing the fragments, or better still, by turning down a scalp flap with the periosteum, using the original wound as one of its sides. Or one can make 2 scalp flaps with the periosteum, the original wound being between them.

The fractured area is surrounded by drill holes, the thickness of the bone measured, and with the properly guarded saw, cut between the holes. The bone is then cracked with an osteotome placed in the saw cut and the pieces removed. Any blood clot is removed with a scoop or by an irrigation with hot salt solution. The bleeding is checked and the lacerated dura sutured if possible, otherwise celloidin or Cargile membrane is placed over it.

If the bone is not soiled, infected, or too minutely comminuted, and the dura is intact, it may be replaced and the scalp wound carefully sutured with good free rubber tissue drainage.

If the bone fragments are soiled and there is any danger of infection, or if the dura is lacerated so that these numerous rough fragments would rest on the unprotected brain, they had better be left out entirely and at some future time a bone graft or celluloid plate inserted.

Fracture with Symptoms of Intracranial Hemorrhage.—In cases where there are well-marked symptoms of intracranial hemorrhage and its location can be accurately determined one of the regularly described osteoplastic flaps for exposing that region may be turned down. This requires no longer than the trephine opening and its subsequent tedious enlargement with the rongeurs. A good free opening is obtained which greatly facilitates the accurate examination of the extent of the lesion, and gives the surgeon the best possible chance to find and control the bleeding points. The return of the flap and the careful scalp suture give the patient the shortest possible convalescence, the minimum risk of late complications and a protecting cranium as good as before the accident.

Fractures with Fairly Positive Signs of Intracranial Hemorrhage but No Localizing Signs.—These cases often recover without any surgical interference. Others are treated expectantly until very suddenly alarming symptoms develop and respiratory or cardiac failure supervenes before anything can be done.

Still others are trephined and rongeured at the point where the lesion is most probably located. Nothing is found and nothing further is done, and the autopsy shows an extensive hemorrhage, perhaps on the other side, at the cerebellar fossa, under the occipital or frontal lobe.

It is often very hard to decide which cases should be operated upon and which should be treated conservatively.

There is a combination of hemorrhage and lacerated brain and unless the clot is large enough to cause pressure and interfere with the function of important centers, or by its pressure cause edema and interference with the circulation, operation will probably not be indicated.

However, if there is any pressure from the clot, its early removal will do much to aid nature in repairing the contused and lacerated brain, and will also lessen the danger from late secondary changes in the clot and the lacerated area.

Cases which justify any interference at all surely justify one of sufficient thoroughness to furnish positive information of the condition in each fossa of the skull.

Some method must be selected which is rapid, easy, and devoid of shock and which in most cases can be done under local anesthesia or very light general anesthesia. For this purpose a medium-sized trephine 1.5 to 2 cm. (3/5 to 4/5 inch) is well adapted.

Although there are no definitely localizing signs, there may be regions toward which the symptoms point more strongly than others and these should be explored first. After the application of the tincture of iodin and the injection of novocain, a short incision 4 to 5 cm. (1 3/5 to 2 in.) is made in the soft parts down to the bone, and another injection of novocain made in the periosteum before it is pushed back. The bone is trephined and a short cut made in the dura through which a narrow brain retractor, which can easily be bent, may be introduced with sufficient gentleness to press the brain away and give the operator a good view in every direction.

This should be sufficient to show the presence or absence of any dangerous hemorrhage or clot. If nothing is found, the dura is sutured, the button of bone may or may not be replaced, and the scalp sutured. This procedure is quickly and systematically performed in the following regions in the order which the symptoms seem to indicate: the lower part of the midle fossa, the middle of the cerebellar fossa, over the occipital lobe of the cerebrum above the tentorium, and for the frontal lobe; first on one side and then on the other.

The skin incision and trephine opening should be so placed that if an intracranial condition requiring further surgical treatment is found, they may be used in the subsequent formation of the appropriate osteoplastic flap. A general anesthetic would probably be required if further work were to be done.

In all cases of head injuries and cases of suppuration in the scalp, skull and accessory sinuses which suddenly or gradually develop intracranial symptoms of any kind, one should have in mind the possibility of a brain abscess and make frequent and thorough examinations with this in view.

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